Scott Islands Marine Wildlife Area Study Area – An Ecosystems Overview Report

Kevin Fort, Krista Amey, Michael Dunn

Pacific and Yukon Region

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SCOTT ISLANDS MARINE WILDLIFE AREA STUDY AREA – AN ECOSYSTEMS OVERVIEW REPORT

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2006

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Foreword

Ecosystem Overviews are an important component of Environment Canada's Protected Areas Policy and Procedures Manual and as such are a requirement for any process working toward the establishment of Marine Wildlife Areas in Canada. This overview too, specifically fulfills part of Environment Canada's commitments to the shared objectives articulated in the Canada – British Columbia Memorandum of Understanding on the Implementation of the Canada Oceans Strategy for Pacific Canada. Additional conditions identified in the subsequent subsidiary agreements under this MOU are also partially met, particularly under the subsidiary memorandum of understanding focusing on a collaborative approach to establishing a system of marine protection areas for Pacific Canada by 2012.

The purpose of this Ecosystem Overview is to provide a synopsis of knowledge on the physical and biological processes which operate within the Study Area. It is based on existing information and no new data was collected in preparing this report. The sources of information were varied and included primary literature, government in-house reports, and communications with specific experts or managers in the various subjects covered. Its intent is to briefly describe the full range of values within this marine area and provide an indication of the real or potential threats that may be found there.

Executive Summary

Context: The 2 581, 000 ha Scott Marine Area surrounding the Scott Islands archipelago, a portion of which is being considered for designation as a Marine Wildlife Area (MWA), encompasses a productive and diverse marine environment. This Ecosystem Overview Technical Report provides a synthesis of the physical and biological attributes of this marine region, as gleaned from a diverse array of research programs. We used primary and grey literature sources pertaining to the region, as well as unpublished data provided to us by academic and government researchers. Where appropriate, we have also used literature from studies outside the region to make inferences where local information is lacking.

Introduction: It is recognized that the implementation of Canada's Ocean Strategy on the Pacific Coast will involve the development of a system of Marine Protection Areas (MPnAs). Environment Canada possesses the legal authority to establish MWAs through the *Canada Wildlife Act*. The Canadian Wildlife Service's Scott Islands MWA study area is intended to meet the criteria of candidate MPnAs under the draft Subsidiary Memorandum of Understanding for a system of MPnAs on the Pacific Coast of Canada.

Physiography and Oceanography: About 60 % of the study area is situated on the continental shelf, where the tertiary bedrock layers are variously overlain by glacial tills, muds, sands and gravels. The continental shelf bisects the study area. Shoreward of the shelf break, the continental shelf consists of several deep troughs separated by extensive banks. Seaward of the shelf, the seabed slopes sharply down the continental slope and rises to the abyssal plain. Portions of the Juan de Fuca and Pacific plates underlie this region of the study area. The Queen Charlotte Fault system transverses the area on a generally northwest by southeast direction. Climatic and weather conditions in the study area vary seasonally, being characterized by strong cyclonic winds and high seas from the southern quadrant in the winter and more variable anti-cyclonic winds and calmer seas during the summer months. During summer, wind-generated southerly currents create upwelling conditions along the shelf-break, bringing cold, nutrient-rich waters to the surface. Large-scale inter-annual and inter-decadal fluctuations in oceanographic conditions have been documented in the northeast Pacific, and these have been linked to marked changes in the biotic community.

Geology: The Cretaceous and Miocene plays of the Queen Charlotte Basin, overlap the MWA study area. Within the study area, these two plays have a combined estimated oil potential of between 87 and 519 x 10^6 m^3. The mean values of in place volumes of potential gas

are between 72 and 254 x 10^9 m^3. Concentrations of titaniferous minerals have also been found throughout the Queen Charlotte Basin. Significant volumes of methane gas hydrate accumulations are inferred along the Pacific continental margin and are found within the study area.

Sponge Reefs: The southernmost of five hexactinellid sponge reefs located in the Hecate Strait and Queen Charlotte Basin is located within the Scott Islands MWA study area. These recently discovered structures are unique in the world, and remain largely unstudied. Fisheries activities, particularly bottom trawling, pose a threat to sponge reefs, and indeed there is already evidence that structural damage has occurred. In 2002, Fisheries and Oceans Canada (DFO) recommended the creation of 9 km buffer zones.

Plankton: Unlike other regions in the northeast Pacific, the study area is not characterized by a prolonged peak of primary productivity followed by prolonged summer lows. Instead, regular inputs of upwelled water into the euphotic zone produce a pattern of episodically high chlorophyll concentrations throughout the summer months. As a result, dense phytoplankton blooms often occur, providing the foundation for a rich and varied food web. In addition to this seasonal variation, phytoplankton densities also exhibit a large degree of inter-annual variation, much of which is attributed to largescale oceanographic events such as El Niño.

Zooplankton communities in the region are diverse. Euphausiid (krill) and calanoid copepod species are among the most numerous and biologically important, as they constitute dietary staples for many species of birds, fish, and marine mammals. As with the phytoplankton, biomass and species composition exhibits a large degree of seasonal and inter-annual variation. In years characterized by warmer ocean temperatures, zooplankton peak abundance is earlier and total biomass declines. These shifts have been linked with periods of poor reproductive performance among species of colonial seabirds breeding at Triangle Island.

Seabirds: The Scott Islands MWA study area supports a wealth and diversity of pelagic bird species. Well over 2 million seabirds (12 species) breed on the Scott Islands themselves. Many of these species are present in the Scott Islands MWA study area in globally or nationally significant numbers. Researchers at Triangle Island have also shown, through radio-telemetry studies, that locally-breeding alcids forage widely over much of the study area during the critical breeding period. Other studies at Triangle Island have suggested a link between reproductive success of various seabirds and fluctuations in key oceanographic parameters. In addition, large numbers of non-breeding visitors, including some globally and nationally threatened and endangered shearwater and albatross species, forage extensively in the study area during the summer and early fall.

Marine Mammals: The study area also represents important habitat for many species of marine mammals. Although less abundant than in the past due to historical whaling practices, the study area represents important migratory and foraging habitat for such species as Grey Whale, Humpback Whale, and endangered Blue Whale. Toothed whales, including a number of threatened and endangered populations of Killer Whale, also utilize the region extensively. Approximately four thousand Steller sea lions breed at four locations in the Scott Islands. The Triangle Island rookery (currently Canada's largest colony and second largest in the world) produced 2199 pups in 2002. Although extirpated from BC in the 19th century, sea otters are beginning to re-colonize the area, which likely represents high quality habitat for this species

Fish and Marine Invertebrates: A diversity of marine fishes is also present in the study area. The groundfish, which include many commercially harvested species such as rockfish, Pacific halibut, sablefish, and sole, comprise an economically important subset. Also, stocks of all five salmon species are present during various phases of the marine component of their life cycle, including juvenile migration and as returning adult spawners. Some stocks of conservation concern, such as Snake River Chinook (a U.S. endangered Columbia River stock) and Owikeno (Smith Inlet) Sockeye, are also known to use the region. A number of smaller pelagic fish species are present, some of which represent important prey items for seabirds in the study area. Many marine invertebrates occur in the study area, although the shrimp trawl is currently the only active invertebrate fishery.

Threats: This section deals with socio-economic activities which may impact biota within the Scott Islands MWA study area. Commercial fisheries pose a potential threat to various taxa through bycatch of non-target species, such as seabirds, marine mammals, and fish. Seabird bycatch in the longline fisheries is of particular concern in the study area, although net fisheries taking place outside of the proposed boundaries may pose a threat to Scott Island breeders such as the Common Murre. Bycatch avoidance devices are available, and in some cases are being implemented, as mitigative measures. Shipping activities may also threaten biological values in the area. Catastrophic spills, such as the *Exxon Valdez* spill, have received the greatest amount of attention to date. However, there is growing evidence that the sub-lethal effects of chronic low-level oil spills may be having a greater impact on populations of marine organisms. Mammalian predators, often first introduced to islands along the BC coast by shipping traffic, pose a very significant threat to Scott Islands breeding seabird colonies. The potential for future oil and gas exploration in the region may result in a number of impacts to seabirds and other marine organisms. In addition to increased frequency and risk of chronic and acute oil spills, seismic surveys conducted during the oil exploration phase and attraction to offshore oil rig platforms also represent potential threats to marine organisms.

Knowledge Gaps: The Canadian Wildlife Service has identified a number of priority knowledge gaps requiring additional study. These include a recognition of the need for demographic and population information on various seabird populations breeding in the Scott Islands. Common Murre is of particular immediate concern, but other species, such as storm-petrels, Pigeon Guillemot, and Brandt's Cormorant have been identified. The extent to which local seabird populations are affected or vulnerable to impacts associated with fisheries bycatch, chronic oil spills and climate change must also be evaluated. In addition, little is known about basic life history information for key forage fish species or seabird adult diet composition. Finally, the extent to which various climatic and anthropogenic factors combine to increase the risk for catastrophic seabird population declines is not known, and predictive models need to be developed to assess this.

Abstract

The 2 581 000 ha study area encompasses a productive and diverse marine environment surrounding the Scott Islands archipelago. More than 2 million seabirds breed on the Scott Islands and they, along with large seasonal populations of many other pelagic birds, rely on the surrounding marine waters for critical foraging habitat. Due in part to rich planktonic communities, the study area also represents important breeding and foraging habitat for many species of marine mammals and fishes, and contains a globally unique hexactinellid sponge reef. This Ecosystem Overview Technical Report provides a synthesis of the physical and biological attributes of this marine region, as gleaned from a diverse array of research programs. Nevertheless, significant information gaps exist on the biology and ecology of the species present in the area. Identified knowledge gaps pertaining specifically to migratory birds and their habitats are provided here. In addition, existing and potential threats to the ecological integrity of the Scott Islands MWA study area are presented and discussed.

Résumé

La zone d'étude, qui couvre 2 581 000 ha, abrite un milieu marin productif et divers qui entoure l'archipel des Scott. Plus de deux millions d'oiseaux de mer nichent sur les îles et, tout comme les fortes populations saisonnières de nombreux autres oiseaux pélagiques, ils trouvent dans les eaux environnantes un habitat d'alimentation essentiel. Avec ses riches communautés planctoniques, la zone d'étude constitue aussi un important habitat d'alimentation et de reproduction pour de nombreuses espèces de mammifères marins et de poissons, et elle abrite un récif d'hexactinellides (spongiaires) unique au monde. Le présent rapport technique constitue une synthèse des attributs physiques et biologiques de cette région marine, et rassemble des données glanées par divers programmes de recherche. Il reste toutefois de graves lacunes en ce qui concerne la biologie et l'écologie des espèces présentes dans la région. Nous signalons ici les lacunes qui touchent spécifiquement les oiseaux migrateurs et leur habitat. En outre, exister et menaces potentielles pour l'intégrité écologique des îles RFM de Scott sont présentés et discutés.

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1. Introduction

1.1 Marine Protected Areas

Canada's Oceans Strategy provides the overall strategic framework for Canada's oceans-related programs and policies, based on the principles of sustainable development, integrated management and the precautionary approach (Government of Canada 2002). In a Memorandum of Understanding respecting the implementation of Canada's Oceans Strategy on the Pacific coast, there is an explicit commitment to work towards a system of Marine Protection Areas (MPnAs). MPnAs can include critical spawning areas and estuaries, fishing refugia, forage areas for seabird colonies and marine areas where migratory marine birds congregate at other times of the year, as well as summer feeding and nursery grounds for whales or other marine mammals (Government of Canada and Province of British Columbia 2003; Figure 1-1). The legal authority to establish a marine protected area may flow from a number of federal and provincial statutes, including the *Canada Oceans Act*, *Canada Wildlife Act*, *Marine Conservation Areas Act*, *BC Ecological Reserves Act* and the *BC Parks Act*. Designation of marine protected areas will be based on sound ecosystem science and environmental and socio-economic technical analysis. MPA management objectives include contributing to the protection of marine biodiversity and providing scientific research opportunities such as the long term monitoring of undisturbed populations.

1.2 Marine Wildlife Areas under the Canada Wildlife Act

The Canadian Wildlife Service administers the Canada Wildlife Act (CWA). This act provides for how the federal government can work with provincial governments, municipal governments and other organizations to research and conserve wildlife. In addition, it gives the Canadian Wildlife Service (CWS) separate powers to create and manage areas for the protection of wildlife. In 1994, the CWA was amended to provide for the creation of protected marine areas (referred to as Marine Wildlife Areas) to be managed for the purposes of wildlife research, conservation, and interpretation. It allows for the creation of protected marine areas in the 12 to 200 nautical mile zone (the 'exclusive economic zone' or 'EEZ', as defined by the international 1982 UN Convention on the Law of the Sea; UNCLOS website). A different regulatory regime is required in this zone, over which Canada has sovereign rights but not sovereignty. The definition of wildlife in the CWA has been amended to include all wild organisms. Consequently, although CWS will continue to emphasize the conservation of migratory birds, the management goal would be to promote ecosystem integrity and conservation for all wild organisms within such an area.

1.3 The Scott Islands Marine Wildlife Area Study Area

This document is intended to provide a comprehensive overview encompassing the geological, oceanographic, and biological features of the Scott Islands MWA study area (Figure 1-2). Potential threats to biota from socio-economic activities in the region are identified, as are research knowledge gaps pertaining to seabirds using the region.

The Scott Islands MWA study area encompasses 2 581 000 ha, and includes shelf, shelf-break, and off-shelf waters. This represents approximately 6% of Canada's Pacific coast marine area. The study area encompasses a productive and diverse marine environment. More than 2 million seabirds breed on the Scott Islands representing over 40% of the total breeding seabird breeding population of the Pacific coast of Canada. These species, along with seasonal populations of many other pelagic birds rely on the surrounding marine waters for critical foraging habitat. The marine area also represents important breeding and foraging habitat for many species of marine mammals and fishes. In addition, a globally unique hexactinellid sponge reef is also contained within the study area boundaries. The objectives for MWA's would include sustaining a marine area's ability to support seabird populations and other biota, and minimize threats to this ability by human activities. Many of EC's international and national responsibilities are supported by this initiative, including the Migratory Birds Convention Act, Canadian Conservation of Biodiversity Strategy, Species at Risk Act, North American Bird Conservation Initiative, the Memorandum of Understanding on Implementation of the Oceans Strategy in Pacific Canada, and national and regional seabird plans.

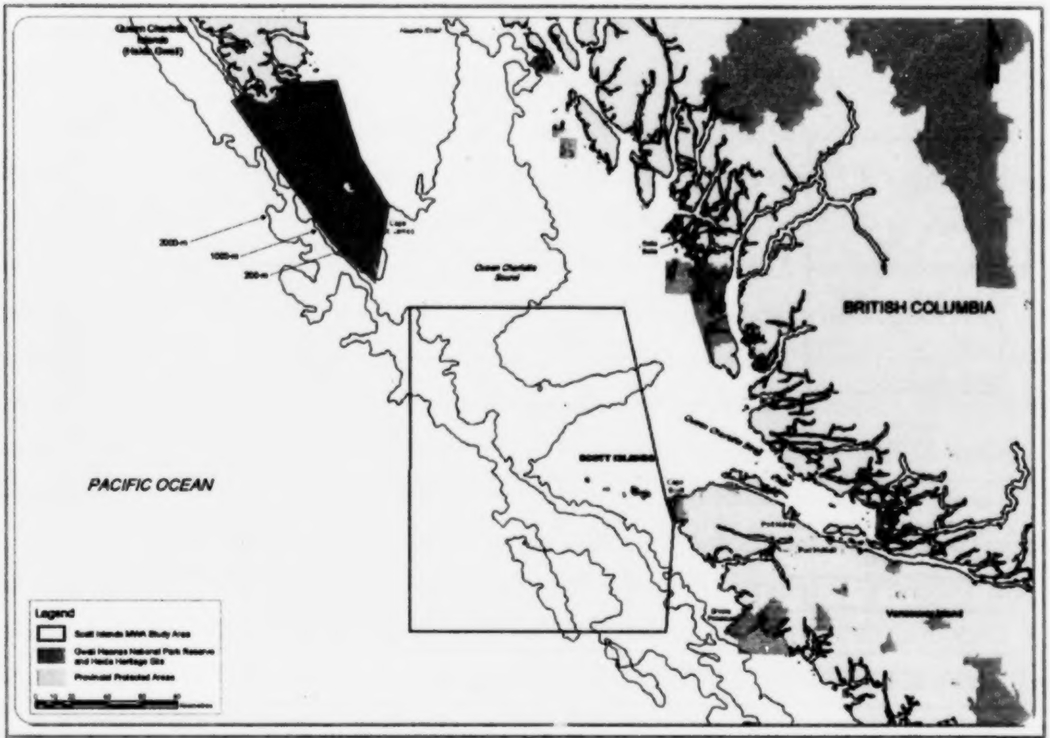

Queen Charlotte Islands (Haida Gwaii)
2000-m
1000-m
200-m
Queen Charlotte Sound
BRITISH COLUMBIA
SCOTT ISLANDS
PACIFIC OCEAN
Vancouver Island
Legend
Scott Islands MWA Study Area
Gwaii Haanas National Park Reserve and Haida Heritage Site
Provincial Protected Areas
Kilometres

Figure 1 - 1 Federal and provincial protected areas in the vicinity of the Scott Islands MWA study area

Data Source: BC Parks, Victoria, British Columbia

Canada

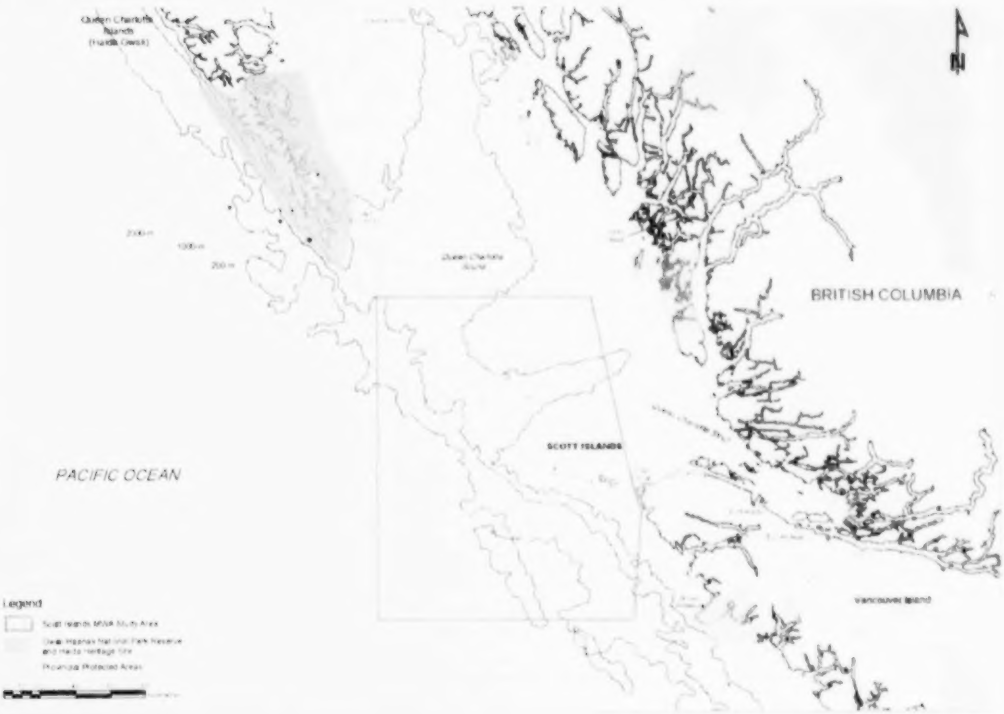

Queen Charlotte Islands (Haida Gwaii)
2000 m
1000 m
200 m
Queen Charlotte Sound
BRITISH COLUMBIA
SCOTT ISLANDS
PACIFIC OCEAN
Vancouver Island
N
Legend
Scott Islands MWA Study Area
Gwaii Haanas National Park Reserve and Haida Heritage Site
Provincial Protected Areas

Figure 1 - 1 Federal and provincial protected areas in the vicinity of the Scott Islands MWA study area.

Data Source: BC Parks, Victoria, British Columbia

Canada

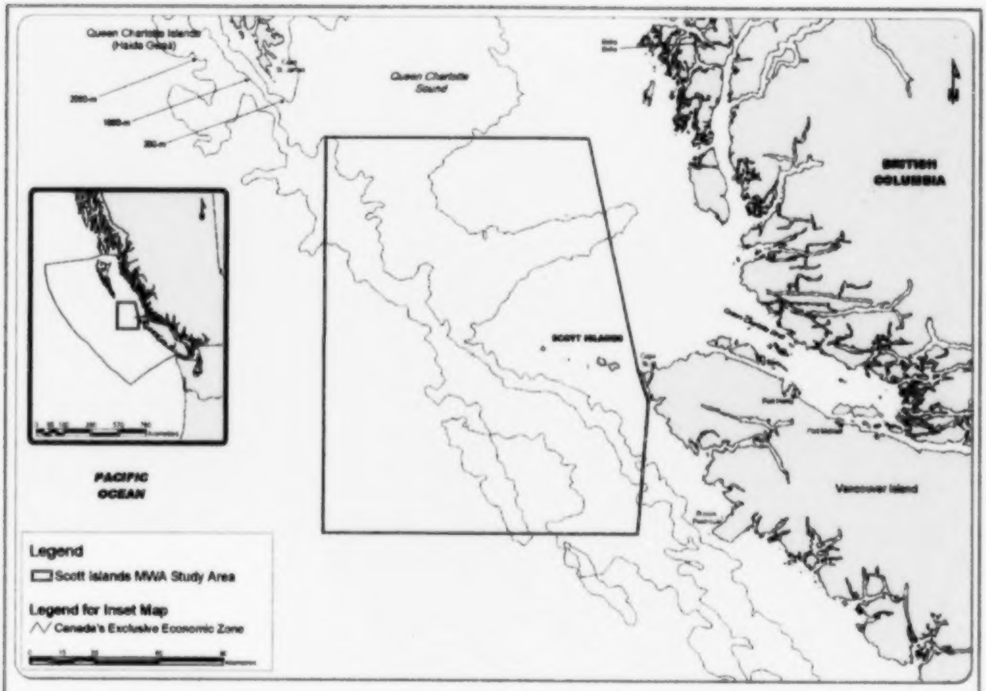


Figure 1 - 2 Scott Islands MWA Study Area. Inset map depicts the Scott Islands MWA Study Area relative to the entire Exclusive Economic Zone

Canada

2. Geology, Physiography, Meteorology, and Oceanography

2.1 Geology and Sedimentology

2.1.1 General Geology and Sedimentology

Approximately 60 % of the Scott Islands Marine Wildlife Area (MWA) study area is situated on the continental shelf (defined here as those areas above the 1800m contour line). This entire area is underlain by gently folded Tertiary and Cretaceous beds, over which a thin layer of Pleistocene and Holocene sediments of the Quaternary period has been deposited (Luternauer and Murray 1969). Barrie *et al.* (1991) identified four surficial geological units among the sediment layers of the Queen Charlotte Basin: 1) glacial till, found primarily in the troughs between banks, 2) glaciomarine mud, deposited by retreating glacial ice, 3) sands and gravels deposited by sublittoral processes, and 4) Wisconsonin/Holocene muds, as well as those associated with the more recent formation of sponge bioherms.

In contrast to much of the Queen Charlotte Basin, the ocean floor surrounding the three outer Scott Islands (Triangle, Sartine, and Beresford) is primarily composed of bedrock and boulders, as well as some areas of sand and gravel (Drever 2002). Cook Bank, a roughly rectangular area (144 km^2) 30 km north of the island, shares these geological characteristics. Little is known about the seabed substrate beyond the continental shelf (Drever 2000), although dredge samples near the base of the continental slopes suggest that the area is underlain by rocks from the late Tertiary Period (Tiffin *et al.* 1972).

2.1.2 Petroleum Geology

The petroleum geology of the Queen Charlotte Basin has been characterized in a recent Geological Survey of Canada report (Hannigan *et al.* 2001). Sandstone and conglomerate deposits have been shown to have good reservoir characteristics. Effective seals for petroleum accumulation are provided when these reservoir strata are inter-stratified with layers of shale, siltstone, and volcanic rocks. Within the Queen Charlotte Assessment Region for petroleum potential, a number of basins and three oil and gas plays have been identified (Figures 2-1 and 2-2). A "play" is defined as a family of pools or prospects that share a common history of generation, migration, reservoir development and trap configuration. Two of these, the Cretaceous and Miocene plays, overlap the MWA study area. The Cretaceous play encompasses most of the Queen Charlotte Islands and adjacent shelf areas. The most prospective part of the play area occurs in a southeast-trending fairway from central Graham Island to southwestern Queen Charlotte Sound (Figure 2-2). Characterized by numerous, small, structurally complex prospects and reservoir zones, this play has an estimated potential median oil potential of 392 x 10^{6} m^{3} of oil. The potential for the Cretaceous gas play is 75 x 10^{9} m$^{3.}$ However, exploration risk is relatively high, as oil and gas accumulations are estimated to occur only in about 11 % or 9% of all prospects within the play, respectively. Occurring basin-wide in an area of 40 000 km^{2}, the Miocene oil play shows an estimated volume of 574 x 10^{6} m^{3} of oil and a gas potential of 286 x 10^{9} m^{3}, and oil and gas accumulations are estimated to occur in 10% and 15% of all prospects, respectively (Hannigan *et al.* 2001).

The conventional and non-conventional oil and gas resource potential of the Scott Islands MWA study area is described by Hannigan *et al.* 2005. The authors note that parts of four of the major sedimentary basins occur within the study area. Using modified areal apportionment of resource potential of the defined plays they have provided conservative and optimistic estimates for the study area. Total volume of in place oil conservatively is estimated at 87 x 10^{6} m^{3} while an optimistic estimate is 519 x 10^{6} m^{3}. For in place gas volumes, the authors used mean values and estimate conservatively that there are 72 x 10^{9} m^{3} potential gas and optimistically that there are 254 x 10^{9} m^{3} within the study area. The estimates are based on resource distribution scenarios where the conservative case assumes the largest oil and gas fields are located outside of the study area while the optimistic case assumes they will be found within the study area.

Hannigan *et al.* 2005 also note that the occurrence of methane gas hydrates is inferred along the whole Pacific continental margin and that there is potential for large volumes to be found within the Scott Islands MWA study area.

2.1.3 Marine Mineral Resources

Significant concentrations of modern heavy mineral deposits have been identified on the British Columbia continental shelf, with particular concentrations occurring within sand samples from the Queen Charlotte Sound and Hecate Strait (Barrie 1994). These concentrations are dominated by titaniferous minerals such as ilmenite, sphene, and titaniferous magnetite. Significant Queen Charlotte Sound concentrations have been found on the northern margin of Cook Bank and the southwestern margin of Goose Island Bank (Barrie *et al.* 1988). These are thought to be lags which result from continuous differential sorting by tidal and wave activity at water depths (optimally, 130-160 m) which inhibit yearly storms from destroying the deposit. This process, however, is likely to produce relatively thin mineral-rich layers. However, thicker layers have been discovered, such as the titaniferous sand deposit on northern Cook Bank. In this case, the deposit is thought to be the product of two processes. In addition to the modern process of differential sorting just described, unidirectional deposition of sediment is thought to have occurred from the adjacent land area by means of a relict channel (Barrie 1991).

2.2 Bathymetry

The Queen Charlotte Basin is cut by three glacial troughs, 10 to 40 km wide with depths up to 400 m, which extend from the shelf break shoreward. These troughs are separated by extensive banks less than 100m deep, two of which are located in the vicinity of the Scott Islands MWA study area. Cook Bank is located just off northern Vancouver Island, while Goose Island Bank is roughly in the centre of Queen Charlotte Sound (Figure 2-3).

The continental margin bisects the Scott Islands MWA study area (Figure 2-3). The continental slope in this region dips steeply (average angle is 10 to 15 °, but local angles of 30 ° or more are common) until it reaches the ocean floor at a depth of 1800-2000m. Steep slope angles are due to down-slope movement of sedimentary blocks on fault planes (Tiffin *et al.* 1972).

2.3 Climate and Weather

Weather conditions in the northeast Pacific are predominantly influenced by seasonal fluctuations in the strength of two major semi-permanent atmospheric pressure cells: the Aleutian Low and the North Pacific High. The Aleutian Low begins to increase in intensity in early fall, while shifting in position to the southeast from the northern Bering Sea to the Gulf of Alaska toward winter. Winter conditions in the Scott Islands region are characterized by stronger cyclonic (counter-clockwise) winds from the southern quadrant (S, SE, and SW). The North Pacific High, a large-scale high pressure cell centered off the central coast of California, strengthens through spring and early summer, as the Aleutian Low weakens. By July, it typically encompasses nearly the entire northeast Pacific, bringing with it variable winds from the northwest (Thomson 1981).

Environment Canada maintains 17 moored meteorological buoys along Canada's Pacific coast. The buoys record hourly wind speed and direction, air and sea temperature, as well as significant wave height and peak period. Four of these buoys are placed in areas representative of the climate conditions within the Scott Islands MWA study area (Figure 2-4). These are East Dellwood (1646207), South Brooks (1646132), South Moresby (1646207), and West Sea Otter (1646204). In addition, weather stations at Sartine Island (1037090) and Solander Island (1037553) collect weather data representative of nearshore marine conditions in the Scott Islands MWA study area. Average monthly air temperatures range from approximately 6 ° C in December and January to approximately 14 ° C in July and August (Figures 2-5 and 2-6). Similarly, average monthly sea surface temperatures range from approximately 8 ° C in March and April to approximately 14° C in August (Figure 2-7). In contrast to the weather buoys, which measure wind velocity just above the surface of the ocean

(5m), windspeeds at the terrestrial weather stations are generally calculated at heights of approximately 30m, which may more accurately reflect the wind conditions experienced by birds in flight (R. Dunkley, pers. comm.) Throughout the year, average monthly wind speeds range from 18 to 45 km/h (Figures 2-8 and 2-9), with the highest average wind speeds occurring during winter storms. Wind velocity tapers during the spring and summer and prevailing winds shift to the northwest as the North Pacific High intensifies (Thomson 1981).

2.4 Physical and Chemical Oceanography

2.4.1 Waves

The Scott Islands MWA study area is subject to strong winds that generate high seas and swell, especially during winter months. Much of the study area is unprotected by the Queen Charlotte Islands, and wave conditions are typical of the open ocean. Significant wave height measurements from three weather buoys in the vicinity of the Scott Islands MWA study area show monthly average wave heights ranging from approximately 1.5 m in the summer months to in excess of 4 m in the winter (Figure 2-10). During the stormy winter months (October to March), seas can exceed 1.5 m in the region 50 % of the time. Hazardous significant waves in excess of 4 m can be frequently encountered during these months, although they rarely exceed 10m. In contrast, seas only exceed 1.5 m 20 % of the time during the summer months (Thomson 1981).

2.4.2 Ocean Currents

The Scott Islands MWA study area is located at the northern end of the North American Coastal Upwelling Domain (e.g. Ware and Thomson, 1991) (Figure 2-11). Prevailing currents in the Scott Islands region are driven by large-scale meteorological patterns and coastal runoff. Nonlinear tidal effects also can lead to mean flow patterns in nearshore regions. In the winter months, prevailing winds generate a persistent northerly wind-driven flow in the offshore region (Figure 2-12). During the summer the direction of offshore currents reverses in response to the shift in prevailing winds associated with the North Pacific High (Thomson 1981; Figure 2-13). The Vancouver Island Coastal Current is a persistent northward-flowing nearshore current generated by brackish outflow from Juan de Fuca Strait in the south and augmented by other freshwater inputs along the coast (Thomson *et al.*1989, Hickey *et al.* 1991, Freeland 1992).

Northerly winds along the outer coast in summer generate southerly currents along the outer shelf and slope which, enhanced by interactions with the steep shelf edge bathymetry, give rise to upwelling conditions along the shelf break, bringing cold, nutrient-rich water to the surface from depths of 100-300m (Mackas *et al.* 2001). The increase in productivity that accompanies upwelling events is likely responsible for supporting observed spatial patterns of habitat use by marine organisms.

2.4.3 Temporal Patterns in Oceanographic Conditions

Oceanographic conditions in the northeast Pacific are known to vary considerably at interannual (i.e. El Niño/La Niña events) and interdecadal (i.e. 'regime shifts') temporal scales. These changes can have a profound effect on the biology of a region through their influence on timing and abundance of local phytoplankton productivity (Bertram *et al.* 2001). For example, the 1990s were characterized by a number of years of anomalously high sea-surface temperatures. Possibly enhanced upper ocean stratification, combined with reduced upwelling-favourable northwesterly winds, resulted in less vertical mixing of the water column, as stronger wind events were required to bring nutrients into the euphotic zone. Nitrate levels in the northeast Pacific were observed to be as much as 60% lower in 1994, an El Niño year, than in 1989, a year characterized by cool sea-surface temperatures and high salinities. This was accompanied by an estimated decrease in primary productivity of 40% in a large patch of ocean west of Vancouver Island (Whitney *et al.* 1998). The decreased primary productivity, together with the reduced strength of the southward currents in summer that accompanied the change in oceanic conditions in the 1990s likely contributed to the observed shift in the timing of zooplankton peak biomass and species distribution (Mackas *et al.* 1998). Since1999, sea surface temperatures have dropped to levels more typical of longterm averages in the region.

2.4.4 Evidence for Climate Change

Although much of the changing conditions can be explained by cyclical patterns, there is also some evidence of a non-cyclical warming trend in sea-surface temperatures of the North Pacific, suggesting to some researchers that increases in global temperatures may be effecting the mixed layer (Roemmich 1992, Freeland *et al.* 1997, Whitney *et al.* 1998). As the warming of the northeast Pacific appears to be associated with lower nutrient availability in the mixed layer (Whitney *et al.* 1998), such a hypothetical non-cyclical trend could have widespread impacts on marine ecosystems, as the resultant decrease in phytoplankton cascades upwards through trophic levels (e.g. reduced zooplankton biomass, lowered fish stocks, poor seabird reproductive performance). At this point, however, there is no conclusive evidence that non-cyclical temperature changes are occurring. However, it is worth emphasizing that the relatively small fluctuations in ocean temperature associated with known cyclical patterns in oceanographic conditions (+/- 2 ° C) may result in large shifts in the character of marine ecosystems.

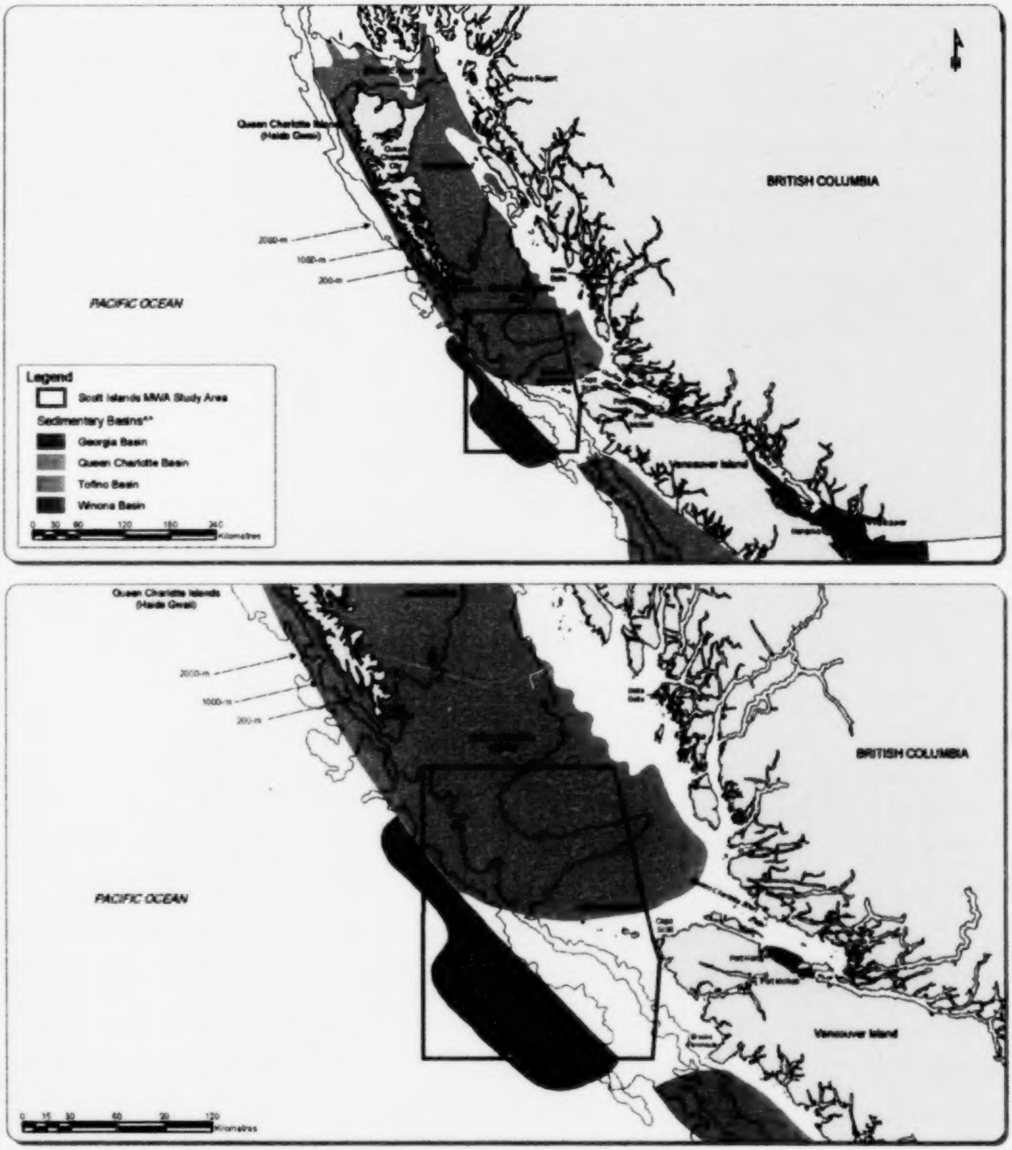


Figure 2-1 BC Offshore Petroleum Potential.

Data Source: Natural Resources Canada

Canada

Produced by CWS GIS Unit
Date: 4 May 2006

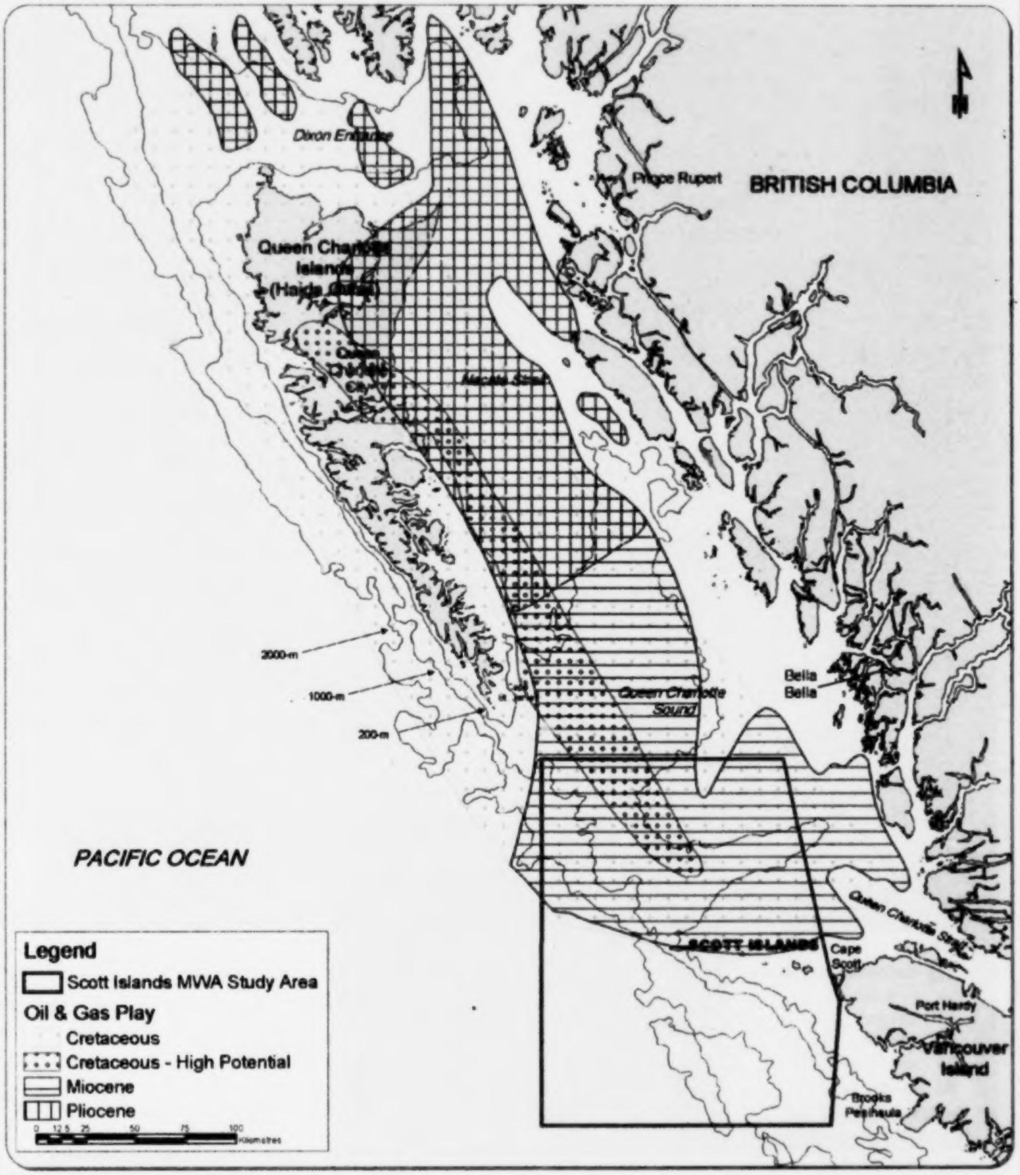


Figure 2-2 Queen Charlotte Cretaceous, Miocene, and Pliocene oil and gas play areas. An area of moderate to high prospectivity within the Cretaceous play is depicted

Data Source: Natural Resources Canada

Produced by CWS GIS Unit
Date: 14 April 2004

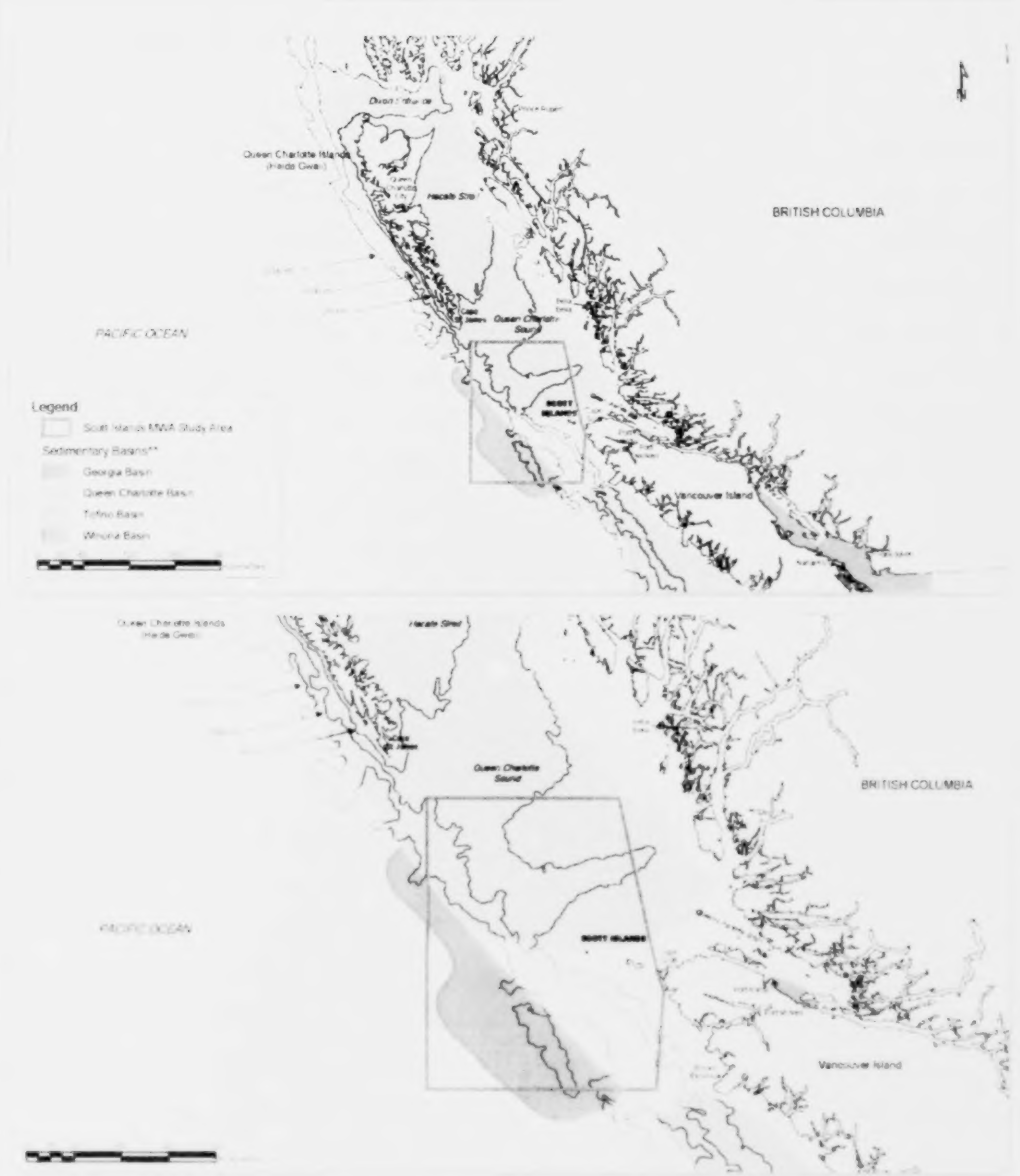


Figure 2-1 BC Offshore Petroleum Potential

Data Source: Natural Resources Canada

Canada

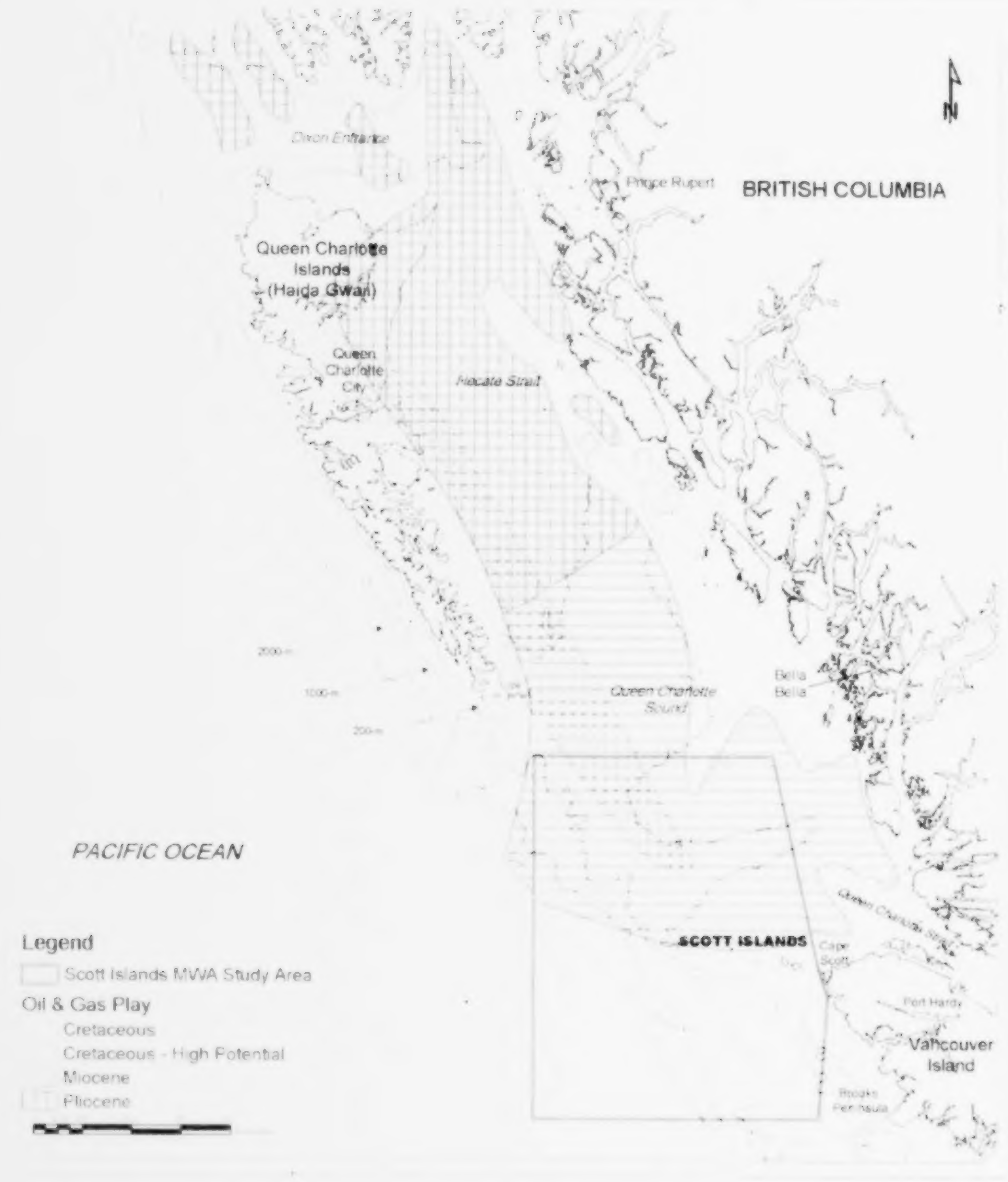


Figure 2.2 Queen Charlotte Cretaceous, Miocene, and Pliocene oil and gas play areas. An area of moderate to high prospectivity within the Cretaceous play is depicted.

Data Source: Natural Resources Canada

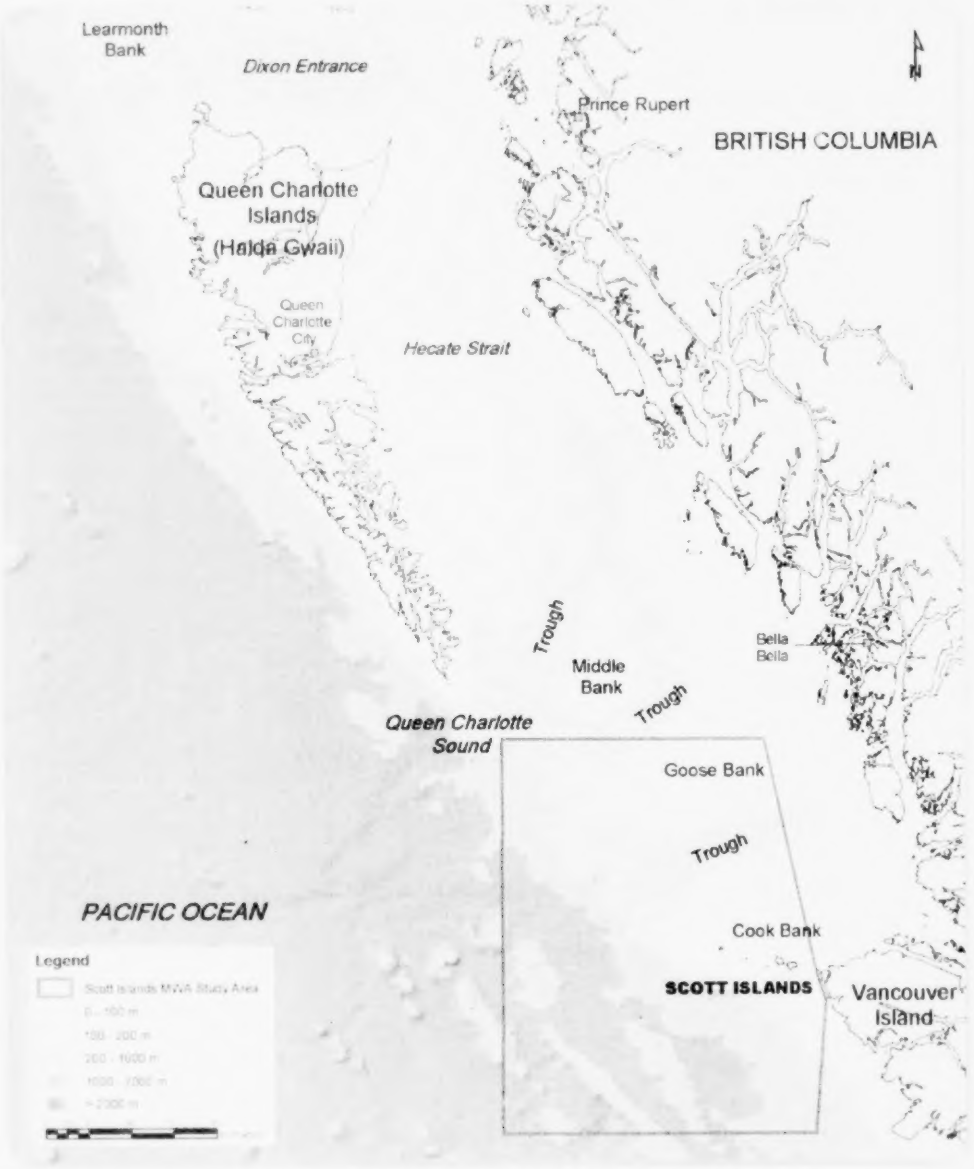


Figure 2-3 Bathymetry in the vicinity of the Scott Islands Marine Wildlife Study Area

Data Source: Smith and Sandwell 1997

Canada

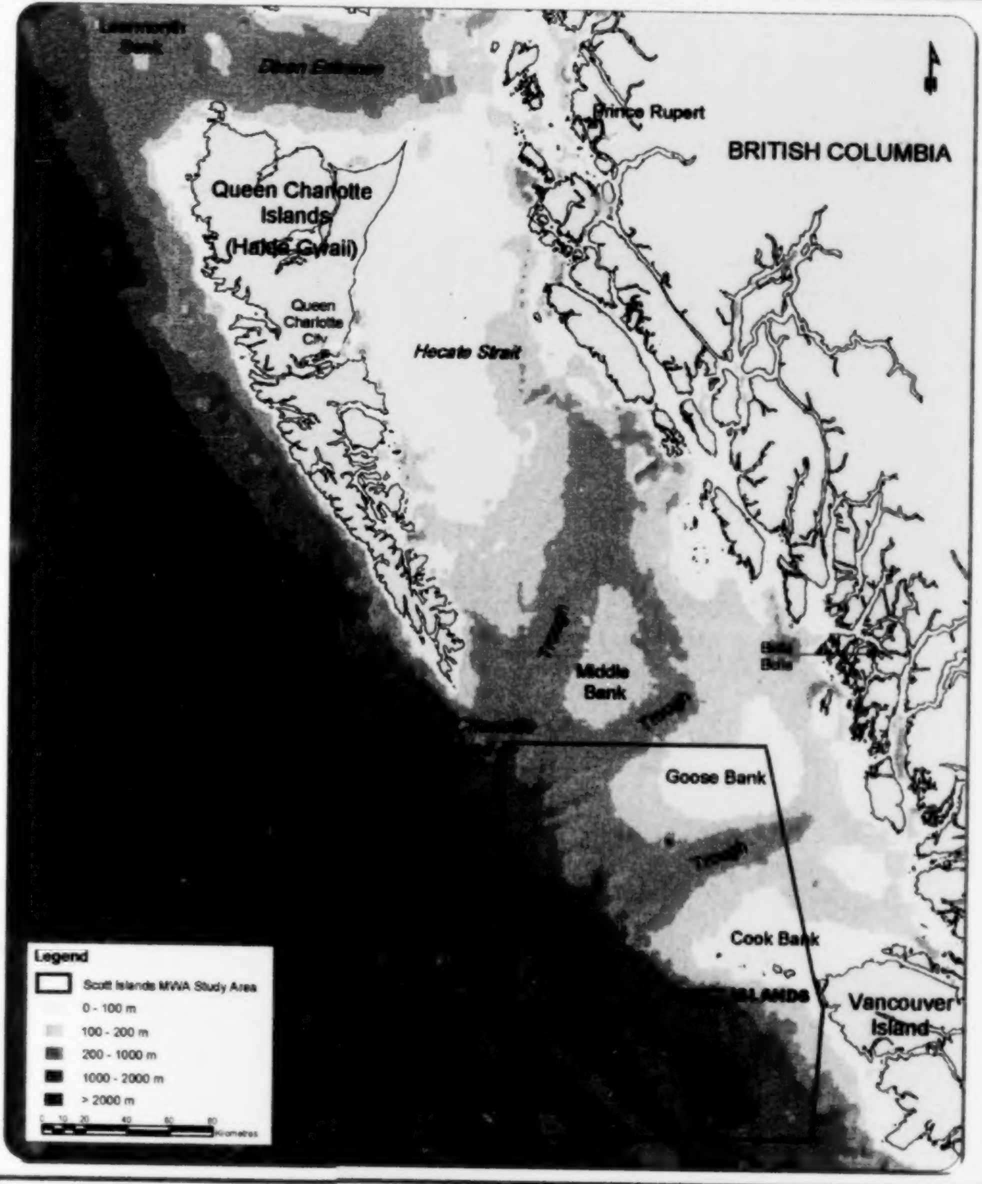


Figure 2-3 Bathymetry in the vicinity of the Scott Islands Marine Wildlife Study Area

Data Source: Smith and Sandwell, 1997

Canada

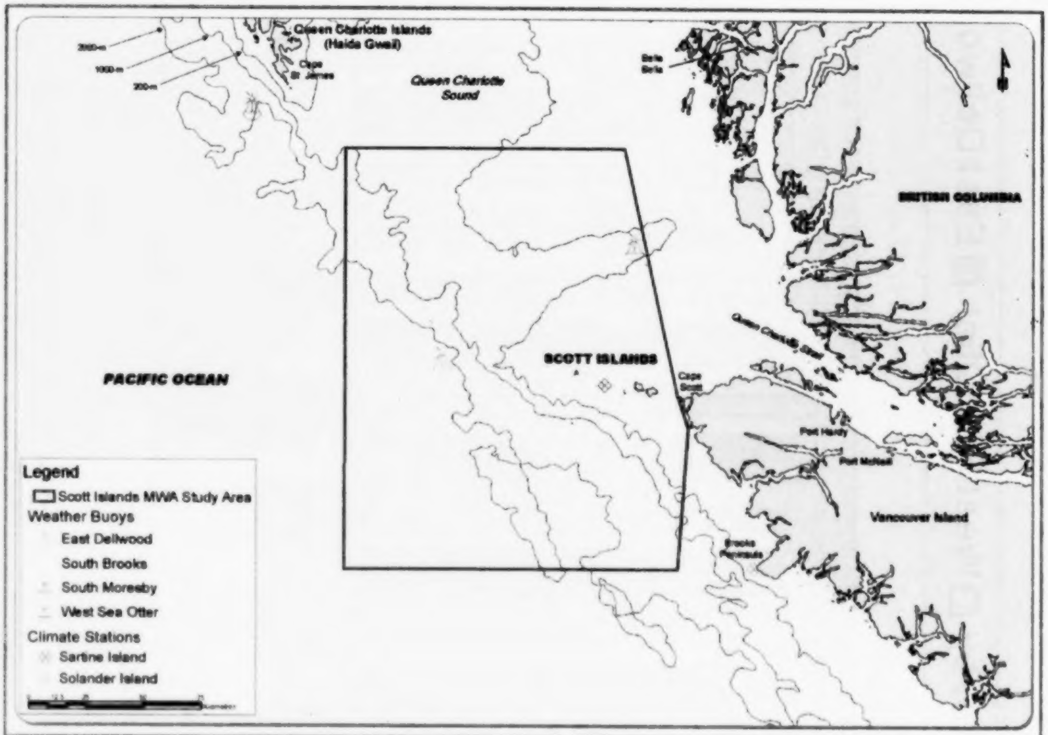


Figure 2-4 Weather Stations and Moored Weather Buoys in the vicinity of the Scott Islands Marine Wildlife Study Area

Data Source: Meteorological Service of Canada, Pacific and Yukon Region

Canada

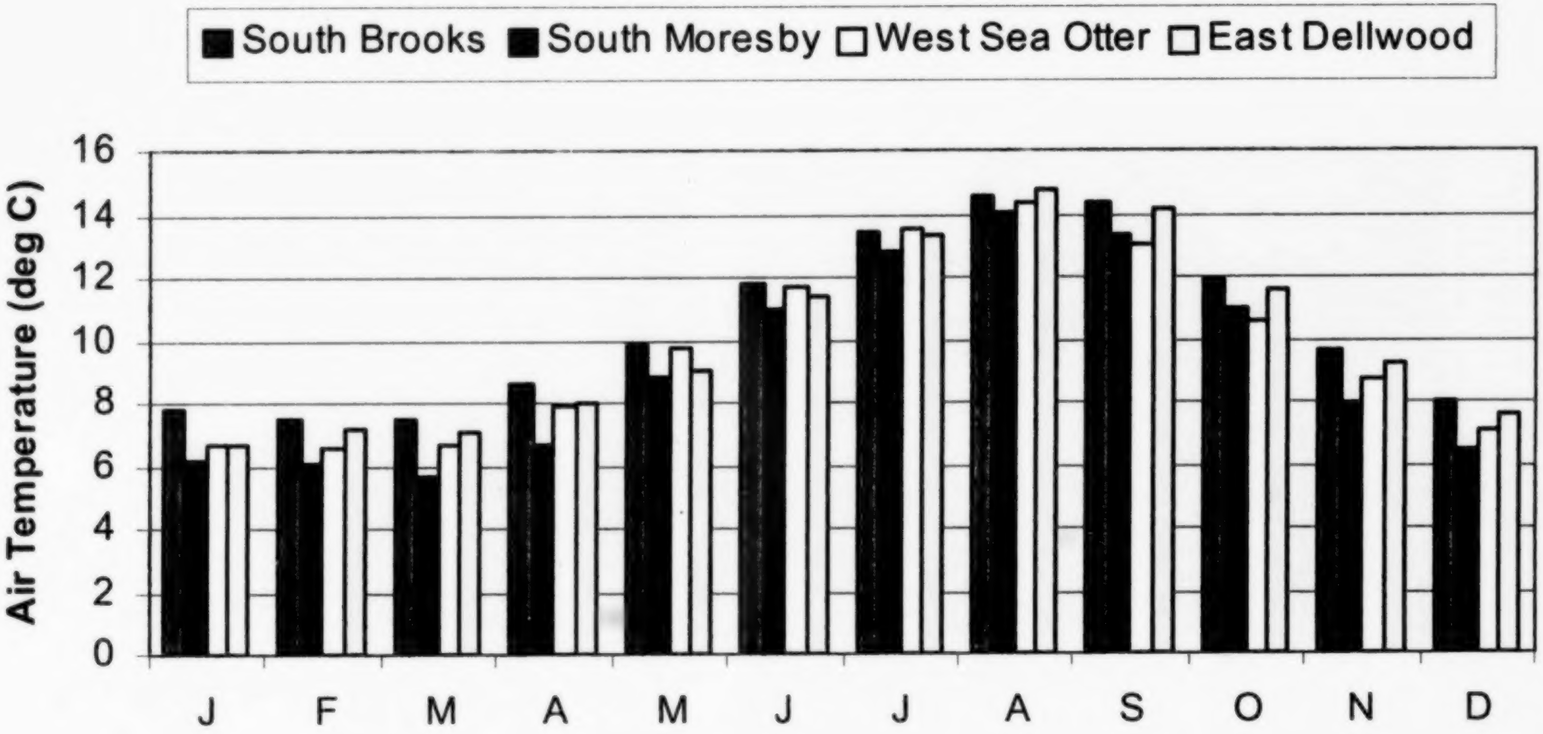


Figure 2-5 Average monthly air temperature measured from four offshore buoys in the vicinity of the Scott Islands MWA study area. Data Source: The official climate archive of the Meteorological Service of Canada, summarized by the Data Management Section of Applications and Services Division.

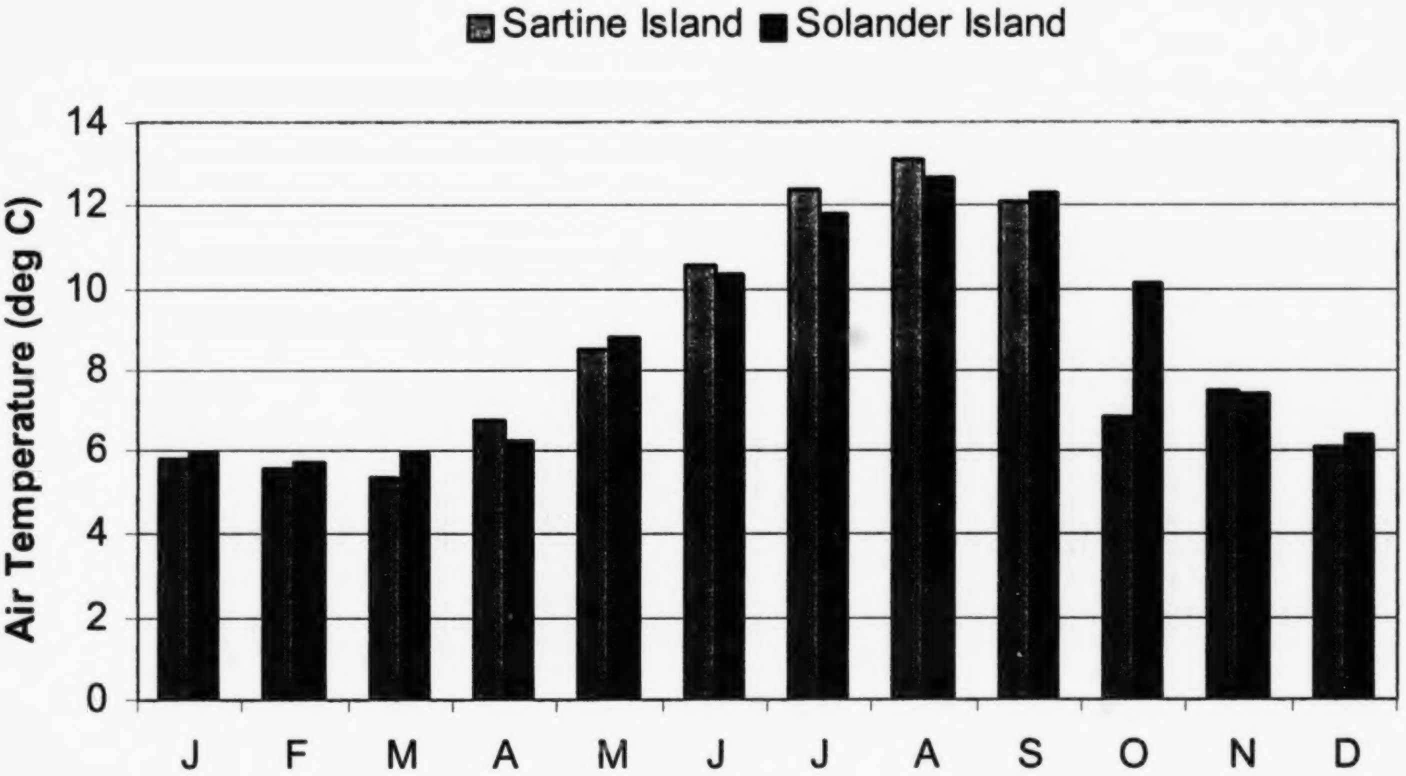


Figure 2-6 Average monthly air temperature measured from two weather stations in the vicinity of the Scott Islands MWA study area. Data Source: The official climate archive of the Meteorological Service of Canada, summarized by the Data Management Section of Applications and Services Division.

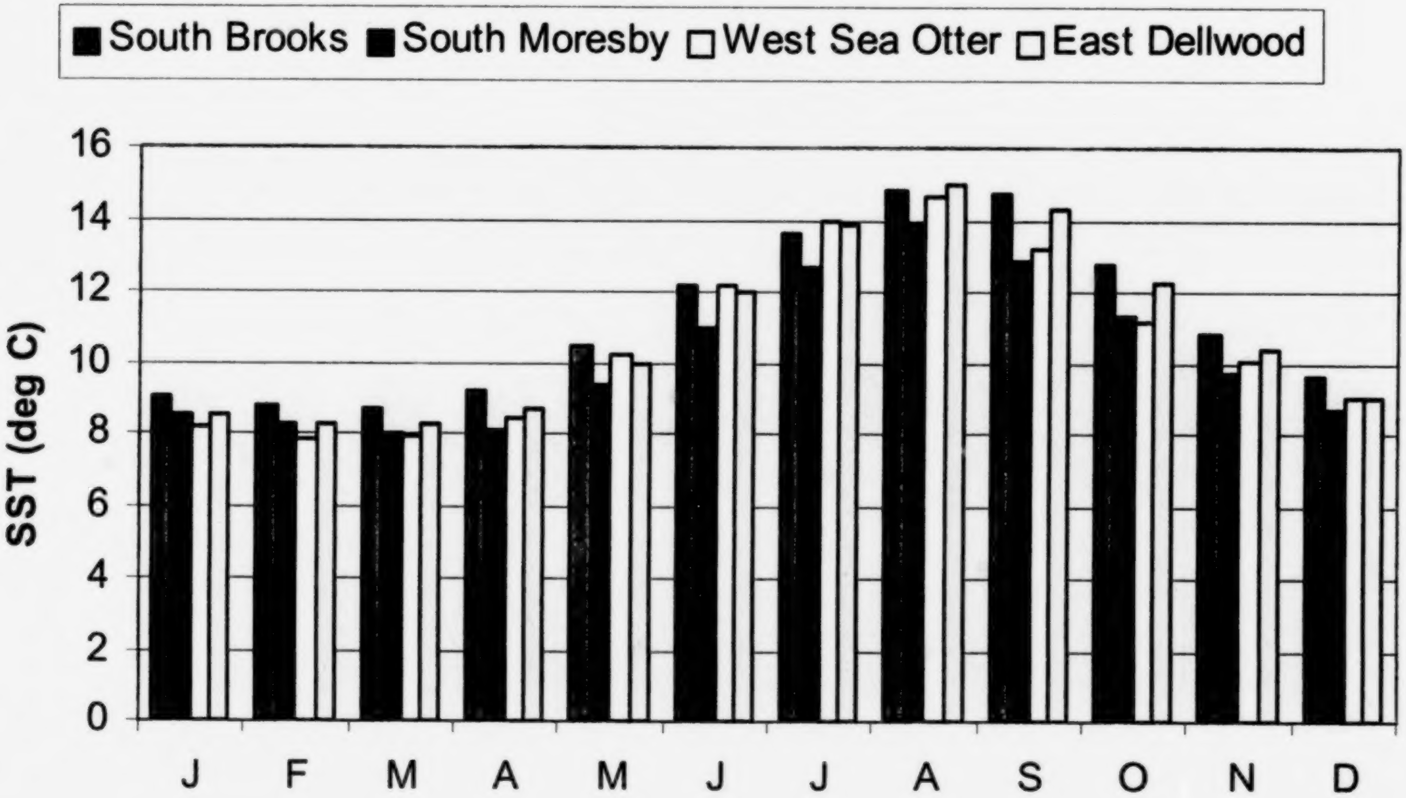


Figure 2-7 Average monthly sea surface temperature measured from four offshore buoys in the vicinity of the Scott Islands MWA study area. Data Source: The official climate archive of the Meteorological Service of Canada, summarized by the Data Management Section of Applications and Services Division.

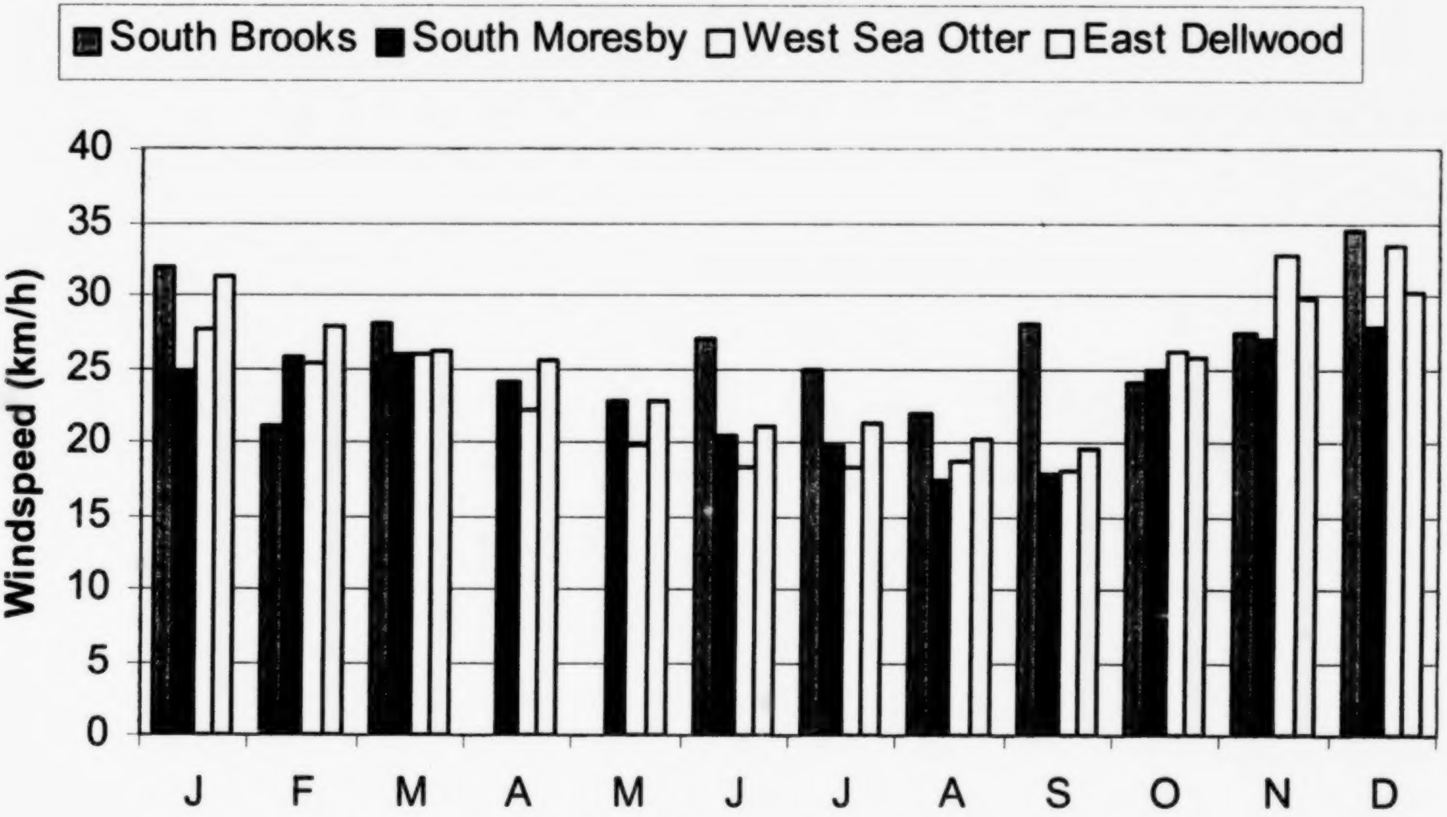


Figure 2-8 Average monthly wind speed measured from four offshore buoys (height: 5 m) in the vicinity of the Scott Islands MWA study area. Data Source: The official climate archive of the Meteorological Service of Canada, summarized by the Data Management Section of Applications and Services Division.

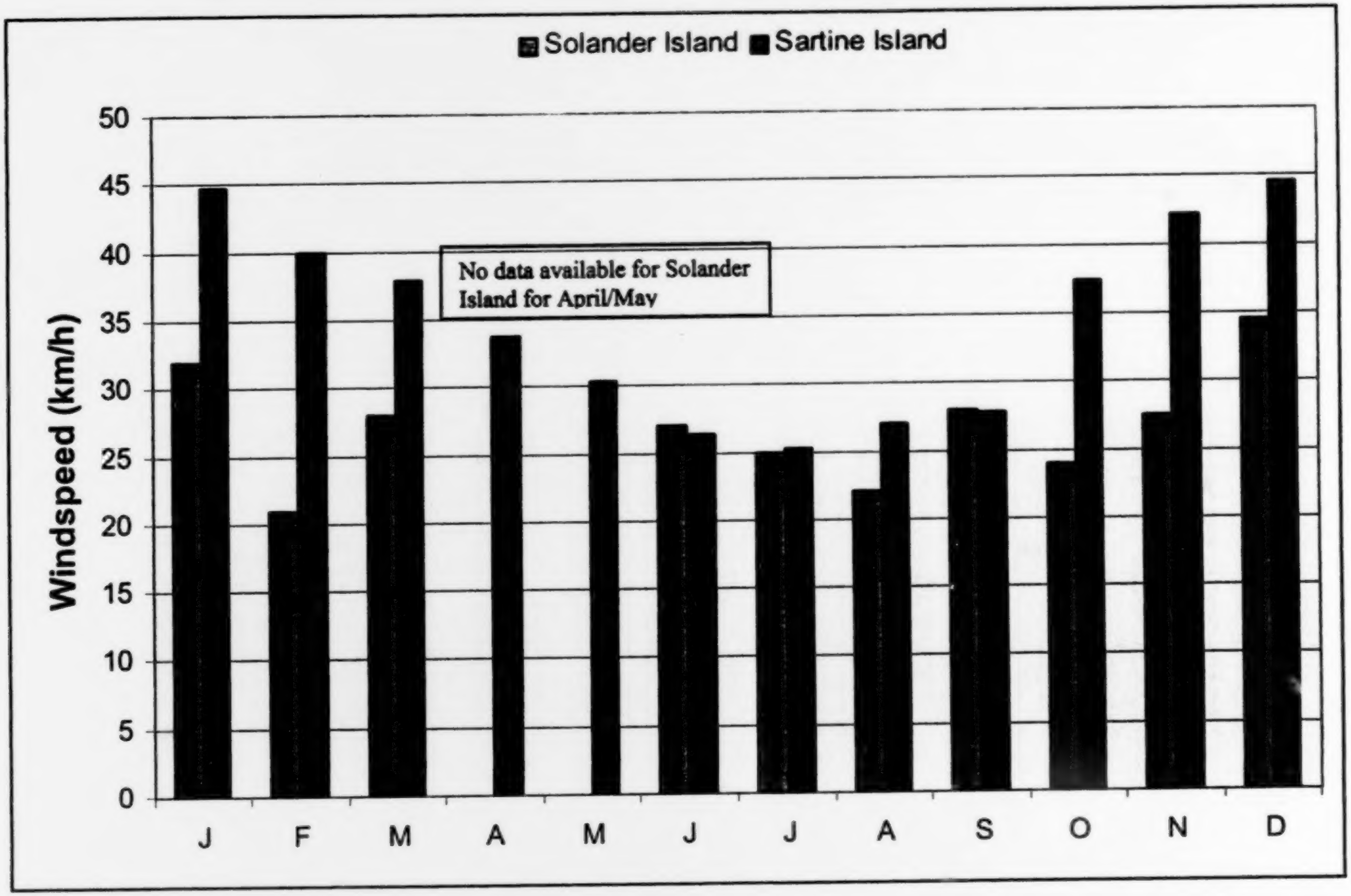


Figure 2-9 Average monthly wind speed measured from two weather stations (height: 30 m) in the vicinity of the Scott Islands MWA study area. Data Source: The official climate archive of the Meteorological Service of Canada, summarized by the Data Management Section of Applications and Services Division.

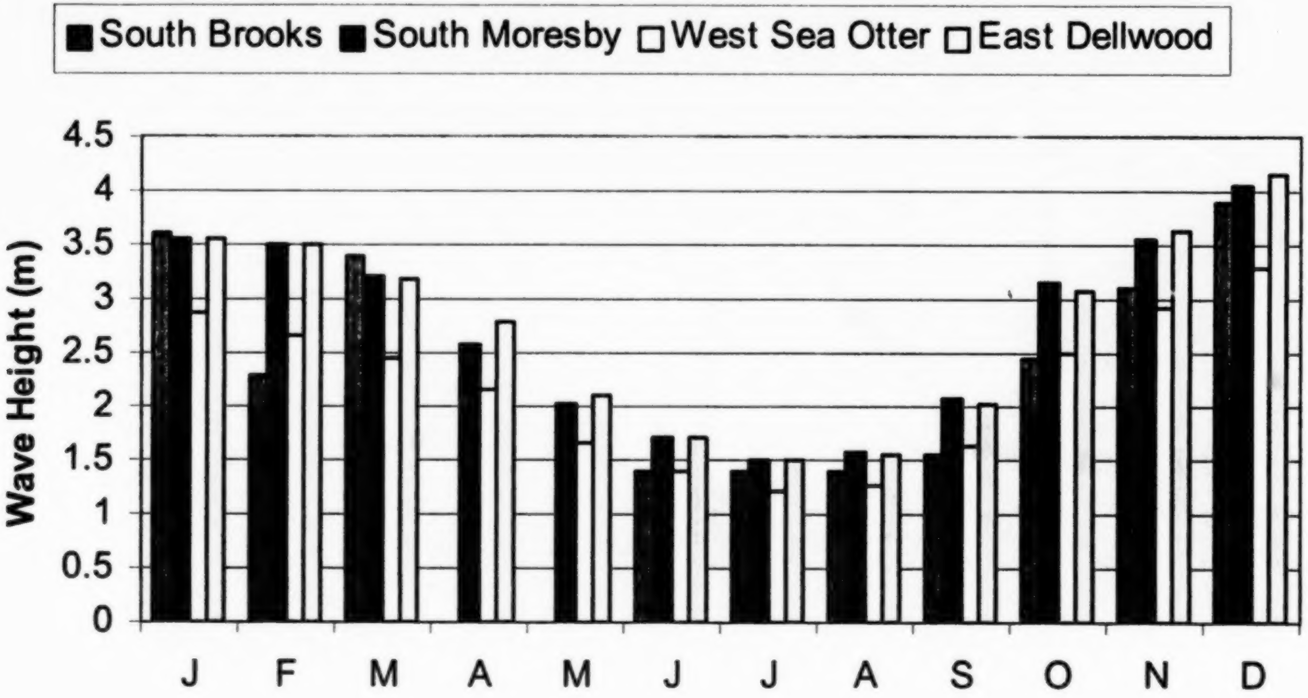


Figure 2-10 Average monthly wave height measured from offshore buoys in the vicinity of the Scott Islands MWA study area. Data Source: The official climate archive of the Meteorological Service of Canada, summarized by the Data Management Section of Applications and Services Division.

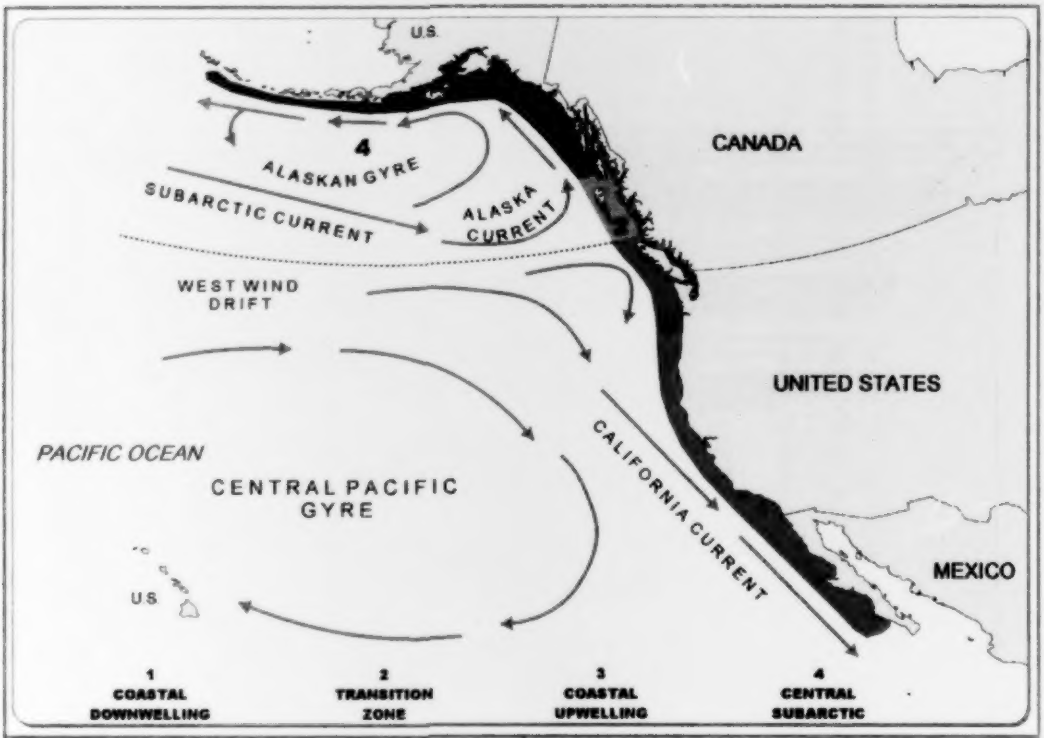


Figure 2-11 Prevailing surface circulation in the Northeast Pacific

Data Source: R.E. Thompson, Fisheries and Oceans Canada

Canada

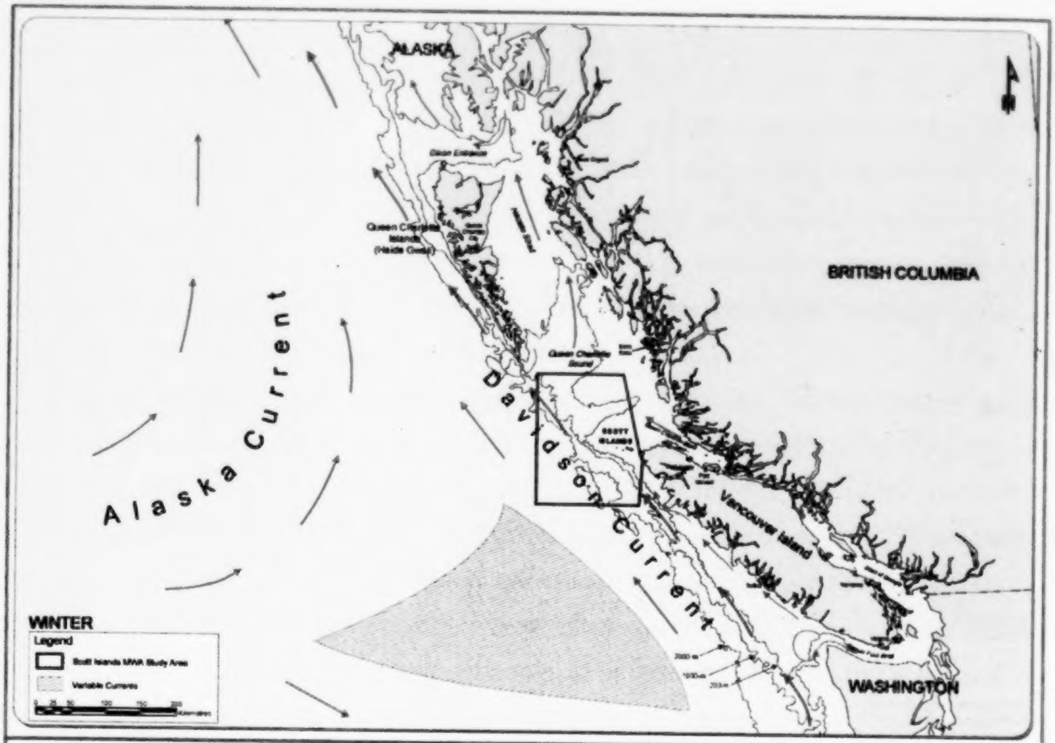


Figure 2-12 Prevailing winter surface circulation off coastal British Columbia

Data Source: R.E. Thompson, Fisheries and Oceans Canada

Canada

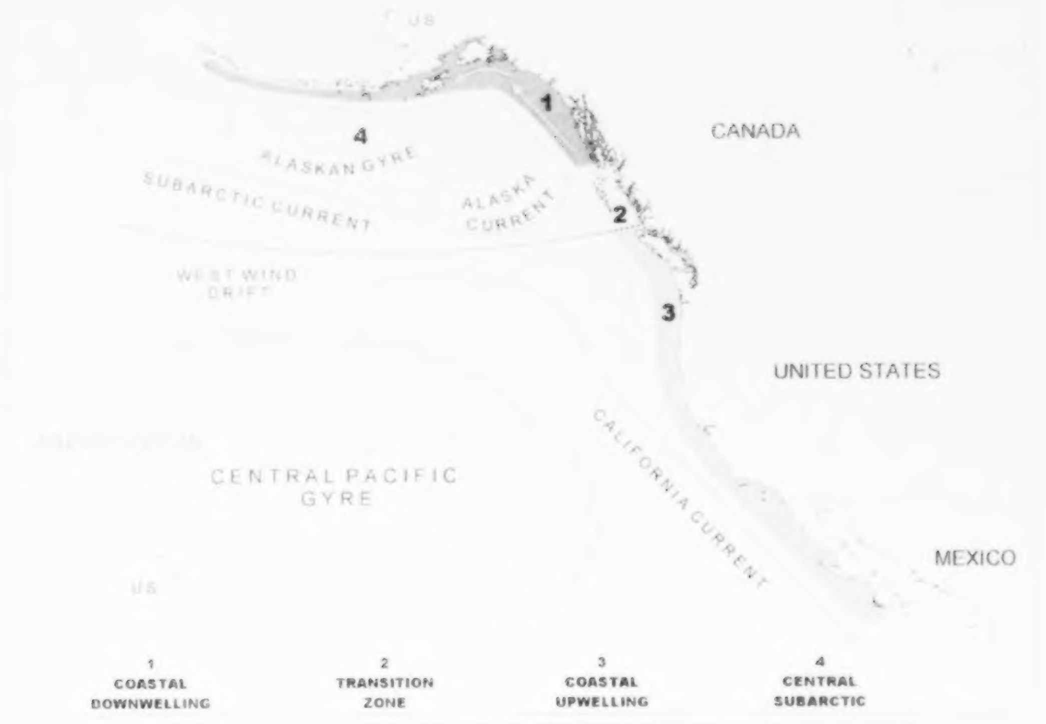


Figure 2.11 [illegible] in the Northeast Pacific

Data Source: R.E. Thomson, Fisheries and Oceans Canada

Canada

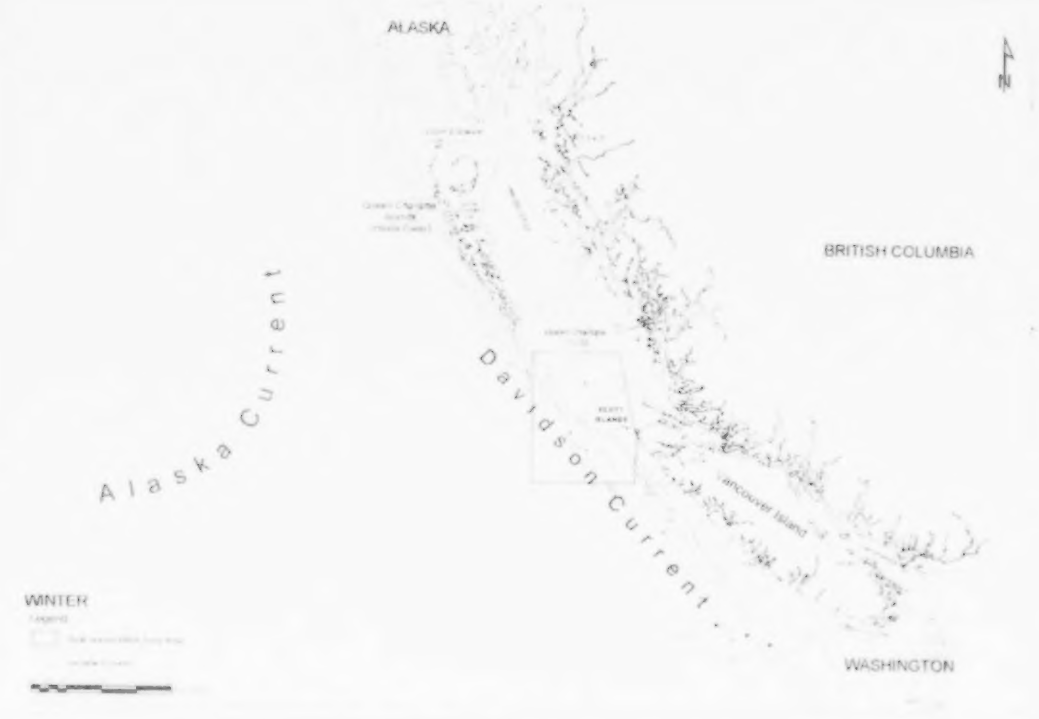


Figure [illegible] Prevailing winter surface circulation off coastal British Columbia

Data Source: [illegible] Fisheries and Oceans Canada

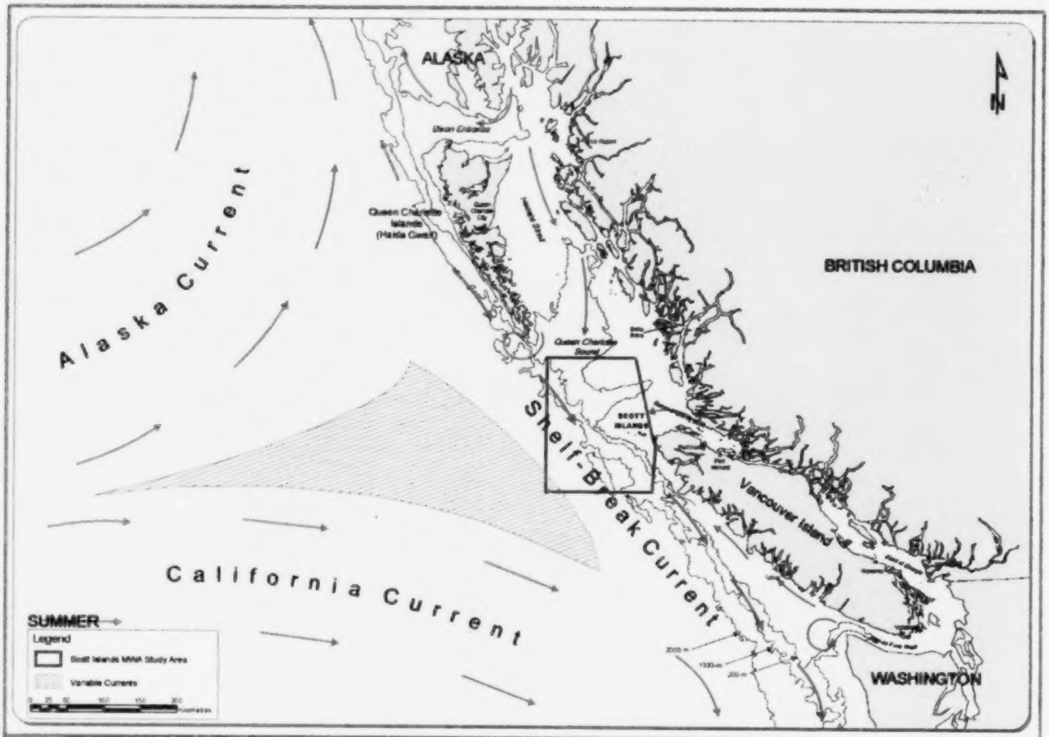


Figure 2-13 Prevailing summer surface circulation off coastal British Columbia

Data Source: R.E. Thompson, Fisheries and Oceans Canada

Canada

3. Plankton

3.1 Phytoplankton

Along the west coast of Vancouver Island, various upwelling processes bring subsurface nutrient-rich water into the euphotic zone where it is used by phytoplankton, resulting in dense blooms. Remaining nutrients, as well as the phytoplankton and zooplankton associated with these blooms, are often transported alongshore or seaward by upper layer currents, which can often result in high densities of zooplankton well offshore of the shelf break (Mackas 1992, Mackas and Galbraith 1992, Mackas and Yelland 1999).

In most temperate marine systems, phytoplankton blooms are characterized by a spring peak, followed by prolonged mid-summer lows. This is a result of nutrient depletion in the euphotic zone following thermal stratification, which prevents additional inputs of nutrient-rich waters from greater depths. However, the Scott Islands MWA study area, as with the coastal Vancouver Island system generally, differs in that the spring decline in productivity is less marked due to subsequent periodic inputs of upwelled nutrient-rich water. As a result, primary productivity remains episodically high throughout most of the summer, resulting in chlorophyll concentration levels that should allow for maximal growth rates in herbivorous zooplankton species (Mackas 1992, Mackas and Galbraith 1992) Although nutrient availability is still relatively high compared to other midlatitude regions, productivity is comparatively low in winter due to light limitation (Mackas 1992).

In additional to seasonal variation, phytoplankton productivity also exhibits a high degree of interannual variability. During the El Niño event of 1998, for example, chlorophyll levels in the region were markedly reduced. This is known to impact abundance and distribution patterns of zooplankton species (see below). In addition, researchers have speculated that advective processes associated with anomalously high levels of freshwater outflow may be responsible for the presence of dense phytoplankton blooms well off the shelf break in 1999 (Figure 3-1 D. Bertram, pers. comm.)

3.2 Zooplankton

Dominant zooplankton groups off northern Vancouver Island include the copepods, euphausiids (krill), chaetognaths, pteropods, and gelatinous salps and jellies (Mackas *et al.*, in press). Euphausiids, an order of planktonic crustaceans, are large and visually conspicuous. Biomass can vary by orders of magnitude over spatial scales of only a few kilometres (Mackas and Galbraith 1992).

Euphausiids are found in the highest concentrations in the immediate vicinity of steep depth gradients, such as the shelf break and upper continental slope (Swartzman 2001, Mackas *et al.* 1997), and are absent from very nearshore environments where bottom depths shallower than about 100m do not accommodate their daily migrations (Mackas 1992). The peak biomass period for euphausiids is late summer through winter.

Copepod crustaceans, especially those of the genus *Neocalanus*, are dominant along and seaward of the shelf break from early spring through midsummer. The life history of *Neocalanus* is characterized by seasonal patterns of vertical migration. Adults mate and spawn in the late summer through autumn at depths of 400 to 2000m (depending on species). Early juvenile stages migrate upward in early spring, and remain in surface layers for 70-100 days before returning to depth to complete the cycle (Mackas *et al.* 1998). Copepod biomass in nearshore environments declines seasonally earlier than their phytoplankton prey availability would suggest, probably due to advective transport offshore of the upper water layers from coastal regions. On the outer shelf, in contrast, zooplankton levels remain high from April through September as declines of deep-water calanoids, which return to depth once they have achieved enough lipid reserves to breed, are offset by the input of coastal species (Mackas 1992).

In years characterized by warmer ocean temperatures, copepod species associated with more southerly regions increase in abundance regionally (Peterson *et al.* 2002, Mackas *et al.* 2001, Mackas *et al.* in press). Unlike the *Neocalanus* species, many of these copepods have multiple generations per year, so the seasonal population abundances peaks are less well-defined than for the more synchronized cohorts of the subarctic copepods. In cold-to-normal years, the highest abundance of the southern taxa is often in winter when the alongshore currents are poleward (Mackas *et al.* in press, Peterson *et al.* 2002).

Salps are typically most abundant in late summer and autumn, but are characterized by 'boom and bust' cycles which make their distribution patterns rather variable from year to year. Salps tend to be more oceanic, and highest abundance in most years is seaward of the shelf break. When present, they often make up a large fraction of the total zooplankton biomass. Occasional influxes of warm offshore waters have been hypothesized to result in periods of high salp dominance, although there is also some evidence of a southerly source in the California Current (D. Mackas and N. Shiga pers. comm.).

The most important zooplankton species for seabirds are the large calanoid copepods species *Neocalanus cristatus* and *N. plumchrus*, both of which are endemic to the open subarctic North Pacific. Due to their seasonal requirement for deep waters, these species are most abundant at and seaward of the shelf break, although they are also numerous along the continental slope. On the continental shelf they are replaced by 'boreal shelf' species such as *Calanus marshallae* (Mackas and Galbraith 1992, Mackas *et al.* in press). Euphausiid species are also consumed by seabirds, and are the principal component of the diets of many baleen whales (Clapham *et al.* 1999).

Overlapping distributions of different zooplankton taxa suggest that the outer continental shelf and shelf break, particularly the area from Brooks Peninsula north to the Scott Islands, should be important for planktivorous seabird species (Mackas and Galbraith 1992). Edges of the deep troughs extending shoreward into Queen Charlotte Sound from the shelf break have also been identified as areas of high zooplankton biomass (D. Mackas, pers. comm.). These suggestions have been supported by seabird pelagic surveys in the region (Morgan *et al.* 1991, Amey *et al.* 2004). High concentrations of seabird breeding colonies on northern Vancouver Island are probably the result of the proximity of the shelf break to the coast, bringing feeding areas closer to potential nest sites, and a latitudinal increase in the abundance of subarctic *Neocalanus* species.

3.3 Temporal Patterns in Zooplankton Availability

Zooplankton community structure, abundance, and timing in the North Pacific are known to vary at a number of temporal scales (Mackas *et al.* 1998, Mackas *et al.* 2001). This variability has been linked to fluctuations in sea surface temperature caused by large-scale climatic events such as The El Niño Southern Oscillation (McGowan *et al.* 1998, Mackas *et al.* 2001). In years characterized by warm ocean temperatures, a shift towards communities dominated by more southerly species has been observed (Mackas *et al.* in press). Off western Vancouver Island, total zooplankton biomass also declined during these times, although the range of the anomalies from the longterm average seasonal cycle is smaller than for anomalies in community composition and the success of individual zooplankton species (Mackas *et al.* 2001). In addition, peak biomass of the copepod *N. plumchrus* occurred markedly earlier in the spring when ocean temperatures were warmer (Mackas *et al.* 1998). This may be responsible for observed poor breeding success of planktivorous seabirds at Triangle Island in years characterized by warm SST's, as peak zooplankton availability may be temporally mismatched with seabird provisioning period food requirements (Bertram *et al.* 2001). In support of this hypothesis, the proportion of copepod prey in nestling diet of Cassin's Auklet (*Ptychoramphus aleuticus*) declined precipitously in late 1997 and 1998, as did nestling growth rates (Hedd *et al.* 2002).

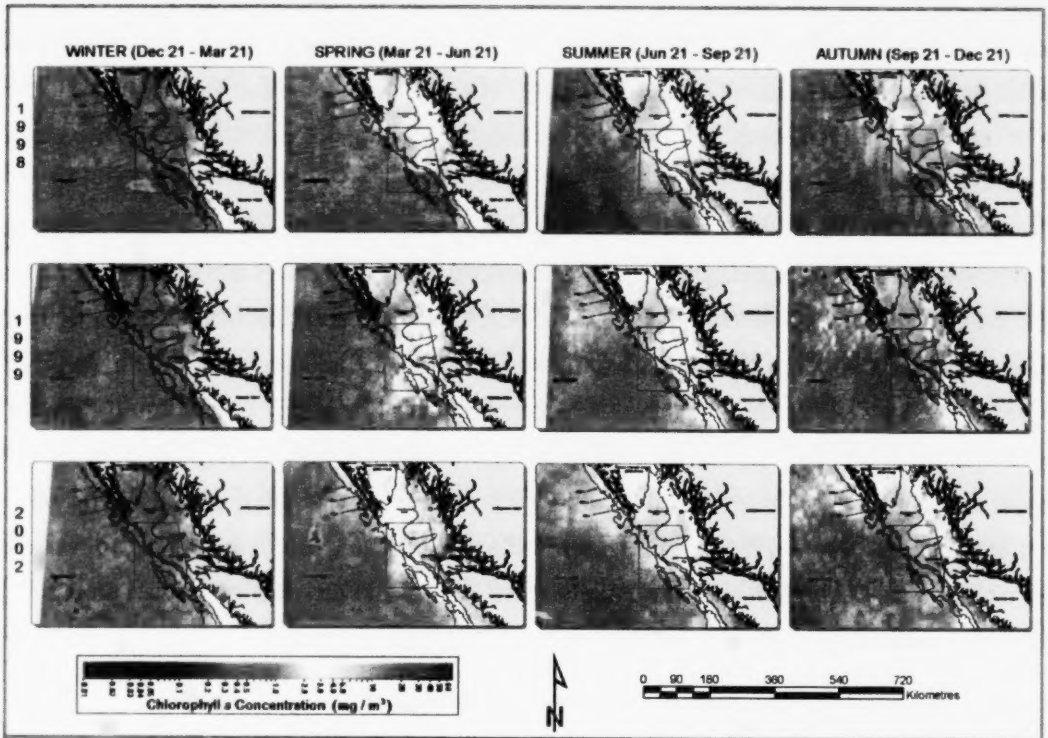


Figure 3-1 Seasonally averaged chlorophyll concentrations for 1998 (El Nino), 1999 (high freshwater outflow), and 2002 ('typical' year) in the vicinity of the Scott Islands MWA Study Area

Data Source: Images provided by the SeaWiFS Project, NASA/Goddard Space Flight Center and ORBIMAGE

4. Seabirds

4.1 Breeding seabirds

The Scott Islands MWA study area contains some of the largest colonies of breeding seabirds on British Columbia coast (Figure 4-1). Twelve seabird species breed on the Scott Islands (7 alcids, 2 storm petrels, 2 cormorants, and 1 gull) and utilize the proposed study area to forage. Three species occur in globally significant numbers (i.e. greater than 1% of the world population): Cassin's Auklet (*Ptychoramphus aleuticus*), Rhinoceros Auklet (*Cerorhinca monocerata*), and Tufted Puffin (*Fratercula cirrhata*). Additional species present in nationally significant numbers (i.e. greater than 1% of the Canadian population) are Brandt's Cormorant (*Phalacrorcorax penicillatus*), Pelagic Cormorant (*Phalacrocorax pelagicus*), Pigeon Guillemot *(Cephus columba)*, Glaucous-winged Gull (*Larus glaucescens*), and Fork-tailed Storm-Petrel *(Oceanodroma furcata*). Nearly the entire western Canadian populations of Common Murre (*Uria aalge*) and Thick-billed Murre (*U. lomvia*) breed on the Scott islands, and significant portions of the western Canadian populations of Leach's Storm-Petrel *(O. leucorhoa)* and Horned Puffin (*F. corniculata*) also breed there (Table 4.1).

4.2 Utilization of Scott Islands MWA study area by other breeding seabirds.

Additional species breeding regionally which also utilize the study area include Ancient Murrelets (*Synthliboramphus antiquus*), Marbled Murrelets (*Brachyramphus marmoratus*), and Mew Gulls (*Larus canus*) (Amey *et al.* 2004). There is suggestive evidence that the waters off the coast of Cape Scott contained within the study area are important for dispersing juvenile Marbled Murrelets. In 2002, juvenile murrelets were radio-tagged in Clayoquot Sound. Of these, 60% dispersed northward along the west coast of Vancouver Island, remaining off Cape Scott for some time prior to disappearing northward, possibly towards Alaska (Figure 4-2; N. Parker, pers. comm.). Marbled Murrelets are listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and have been added to the Species at Risk Act (SARA) Legal List (Schedule 1). They are also considered globally Vulnerable by the International Union for Conservation of Nature and Natural Resources (IUCN). Both organizations identify loss of nesting habitat as the principal threat to this species, although there are also substantial threats from oil contamination and entrapment in net fisheries. Ancient Murrelets breed at a number of locations in the Queen Charlotte Islands, but

Table 4-1. Seabird species breeding on the Scott Islands and their occurrence at the global or national level.

Common Name (scientific name)	*Numbers Breeding (pairs)*	*Percent of Global Population*	*Percent of National Population*
Cassin's Auklet (*Ptychoramphus aleuticus*)	990,000	55	73
Rhinoceros Auklet (*Cerorhinca monocerata*)	41,700	7	12
Tufted Puffin (*Fratercula cirrhata*)	34,900	2	90
Horned Puffin (*Fratercula corniculata*)	11 birds[a]	-	~30[c]
Common Murre (*Uria aalge*)	4,100	-	95[c]
Thick-billed Murre (*Uria lomvia*)	7	-	100[c]
Brandt's Cormorant (*Phalacrorcorax penicillatus*)	39	-	40
Pelagic Cormorant (*Phalacrocorax pelagicus*)	741	-	17.5
Pigeon Guillemot (*Cephus columba*)	619 birds[b]	-	6
Glaucous-winged Gull (*Larus glaucescens*)	1,077	-	4
Leach's Storm-Petrel (*Oceanodroma leucorhoa*)	12,700	-	2.3[c]
Fork-tailed Storm-Petrel (*Oceanodroma furcata*)	3,000	-	1.5

[1] Data from Rodway *et al.* (1990, 1992) and table adapted from Drever (2002)

[a] Suspected breeding

[b] Breeding confirmed, but breeding population not estimated. Number refers to total number of birds in breeding plumage sighted around the colony.

[c] Percentage from western Canada only

individuals of this species occur regularly in the study area during the summer season (Figure 4-2; Amey *et al.* 2004.). However, as distances from the nearest known colony exceed the known foraging ranges of this species, these individuals are probably non-breeders or dispersing juveniles (M. Lemon, pers. comm.). As such, the study area may contain important post-breeding habitat for this species. Ancient Murrelets, which are vulnerable to oil spills and introduction of exotic predators, are a COSEWIC species of Special Concern and will be added to the SARA legal list pending reassessment using the revised criteria. Mew Gulls, which nest in coastal freshwater lakes, were observed in nearshore waters in all seasons but fall (Amey *et al.* 2004).

4.3 At-sea distributions of Triangle Island colonial alcids during the breeding season

The Canadian Wildlife Service, in cooperation with the Centre for Wildlife Ecology at Simon Fraser University, is engaged in a research and monitoring program at the Scott Islands seabird colonies. As part of this initiative, a radio-telemetry study was carried out during the period 1999-2002 to determine at-sea foraging distributions of birds breeding on Triangle Island. Approximately 40 Cassin's Auklets were fitted with radio transmitters in each of the first three years of the study, and aerial surveys were conducted to locate the radio-marked individuals. In 2002, a similar methodology was used to determine at-sea distributions of breeding Rhinoceros Auklets. Results indicated that breeding alcids utilized areas up to 100 km distant from Triangle Island during the breeding season, and the majority of birds were found in areas 30-75 km distant from Triangle Island. Most individuals tended to utilize the same general area in a given year, but exhibited marked interannual variation in location (Boyd *et al.* 2000, Ryder *et al.* 2001, J. Ryder unpubl. data). Figure 4-3 illustrates the distributions of radio-marked individuals of both species in each year of the study.

CWS researchers are working with collaborators at Fisheries and Oceans Canada to link foraging distributions of seabirds with spatial patterns of prey abundance (Bertram *et al.* 2000a). Zooplankton sampling surveys conducted along the "Triangle Line" in 1999-2000 (Figure 4-3) indicate that Cassin's Auklets preferred foraging locations with high concentrations of zooplankton in the upper 50 m of the water column. In 2001, the radio-marked Cassin's Auklets foraged north of the Triangle Line. In that year, the formerly abundant preferred copepod prey was replaced by thaliacean (salp) species at Triangle Line sampling locations.

This suggests that the birds had changed their at-sea distribution in response to changes in prey availability (D. Bertram, pers. comm.).

4.4 Alcid Breeding Population Trends on Triangle Island

Burrow occupancy rates are calculated at 5-year intervals at permanent monitoring plots on Triangle Island for 4 focal species of colonial alcids. During the period 1989-1999, total numbers of active Cassin's Auklet burrows within the plots showed a statistically significant 33% decline, providing evidence for a recent population decline followed by a possible recovery in recent years (CWS, unpubl. data). A long-term mark and recapture study is consistent with this trend (Figure 4-4). This is consistent with concurrent estimates of Cassin's Auklet adult survival rates, which appear to be lower than that required for the maintenance of a stable population (Bertram *et al.* 2000b). However, more recent evidence suggests that this population may be recovering as result of increased recruitment in the years since an oceanographic shift towards colder ocean temperatures began in 1999 (CWS, unpubl. data). Additionally, evidence from 2003 suggests that Common Murres at Triangle Island have declined since the site was last censused in 1996 (CWS, unpubl. data). Consequently, this population is scheduled to be resurveyed in 2004 (M. Hipfner, pers. comm.). There is currently no evidence for population declines of other focal colonial seabirds breeding at Triangle Island (CWS, unpubl. data).

4.5 Breeding performance and success

Breeding success of seabirds on Triangle Island has shown marked inter-annual variation, especially during the last decade. Triangle Island researchers have suggested that food availability and chick diet composition influence various measures of reproductive performance (Bertram *et al.* 2002; Hedd *et al.* 2002; Gjerdrum *et al.* 2003). For example, nestling growth rates of the planktivorous Cassin's Auklet decline as the proportion of their preferred prey item, the copepod *Neocalanus cristatus*, decreases in their diet (Hedd *et al.* 2002). Overall abundance, peak biomass timing, and spatial distribution of zooplankton are known to vary substantially at a number of temporal scales. These patterns are thought to be driven mainly by periodic shifts in the oceanographic and climatic conditions in the northeast Pacific (Mackas *et al.* 1998; 2001). Specifically, zooplankton peak biomass timing and abundance is negatively correlated with sea-surface temperatures. Zooplankton biomass is significantly lower and peak biomass periods are significantly earlier in years characterized by warm ocean temperatures. Lowered breeding performance of Cassin's Auklets and Rhinoceros

Auklets also occurred in warmer years (Hedd *et al.* 2002; Triangle Research Station unpubl. data).

Similar patterns of breeding performance have been detected in the Tufted Puffin (Gjerdrum *et al.* 2003). Although the adults are generalist feeders (Piatt and Kitaysky 2002), Tufted Puffins principally deliver small fish to their chicks. The Pacific Sandlance (*Ammodytes hexapterus*) is a favoured food item for Tufted Puffin, when available. As the sandlance feeds on zooplankton, lower zooplankton abundance and availability may result in the creation of a weak 0+ year class of juvenile fish in warmer years (Bertram *et al.* 2001) or, alternatively, a change in sandlance distribution (Gjerdrum *et al.* 2003).

4.6 Utilization of the Study Area by other pelagic birds

In addition to seabirds breeding on Triangle Island, the study area also supports large numbers of other avian pelagic species. In a report summarizing pelagic seabird surveys conducted over a 20-year period in the vicinity of the Scott Islands and North Vancouver Island, 39 species were detected. Seven are listed nationally or internationally at risk (Table 4-2). Species were placed into one of five categories: Year-round residents (6), Summer-Breeders (11), Summer-Non-breeders (8), Spring and Fall Migrants (3), Winter Residents (3), and Visitors (9) (Amey *et al.* 2004; Figures 4-5 to 4-9). The Scott Islands MWA study area was recognized as being an important area for 13 species (Table 4.2).

On August 12, 2003, researchers at Oregon State University and the U.S. Department of Fish and Wildlife attached a satellite transmitter to a hatch year Short-tailed Albatross (*Diomedea albatrus*) captured in the Aleutian Islands. This individual has since followed the Pacific coast as far as southern Oregon, but was observed to spend a number of days foraging along the shelf break within the MWA Study Area (Figure 4-9). The Short-tailed Albatross is listed as 'Vulnerable' by the International Union for the Conservation of Nature and Natural Resources because of small population size and a breeding range which is limited to Torishima and the Senkaku Islands of Japan (Birdlife International 2000). In November 2003, this species was designated 'Threatened' by COSEWIC (Committee on the Status of Endangered Wildlife in Canada), due in large part to its sensitivity to incidental catch by commercial fisheries and oil spills (COSEWIC 2003a). As with many pelagic birds found within the Scott Islands MWA study area, this species is known to range widely in the ocean environment.

Table 4-2. Avian species detected during pelagic surveys, classified according to seasonal use. Species in bold are species for which the Scott Islands MWA study area is of particular importance (see text).[1]

Year-round residents	*Summer-Breeders*	*Summer-Non-Breeders*	*Migrants-Spring and Fall*	*Winter Residents*	*Visitors*
Northern Fulmar (*Fulmarus glacialis*)	**Fork-tailed Storm-Petrel *(Oceanodroma furcata)***	**Black-footed Albatross*(Diomedea nigripes)*[*]**	**Red Phalarope (S) (*Phalaropus fulicaria*)**	Black-legged Kittiwake (*Rissa tridactyla*)	Common Loon (*Gavia immer)*
Common Murre (*Uria aalge*)	Leach's Storm-Petrel *(O. leucorhoa)*	Laysan Albatross[*] (*Diomedea immutabilis*)	Red-necked Phalarope (S and F) (*P. lobatus*)	Thayer's Gull *(L. thayeri)*	Pacific Loon *(G. pacifica)*
California Gull (*Larus californicus*)	**Cassin's Auklet (*Ptychoramphus aleuticus*)**	**Short-tailed Albatross *(D. albatrus)*[*][**]**	Sabine's Gull (F) (*Xema sabini*)	Xantus's Murrelet *(S. hypoleucus)*	**Double-crested Cormorant *(P. auritus)***
Glaucous-winged Gull (*L. glaucescens*)	**Rhinoceros Auklet (*Cerorhinca monocerata*)**	Buller's Shearwater *(Puffinus bulleri)*[*]			Pomarine Jaeger (*Stercorarius pomarinus*)
Herring Gull (*L. argentatus*)	**Pelagic Cormorant (*Phalacrocorax pelagicus*)**	Pink-footed Shearwater *(P. creatopus)*[*]			Red-throated Loon *(G. stellata)*
Tufted Puffin (*Fratercula cirrhata*)	**Pigeon Guillemot (*Cephus columba*)**	Sooty Shearwater *(P. griseus)*			Long-tailed Jaeger *(S. longicaudus)*
	Ancient Murrelet (*Synthliboramphus antiquus*)[**]	**Short-tailed Shearwater *(P. tenuirostris)***			Parasitic Jaeger *(S. parasiticus)*
	Marbled Murrelet (*Brachyramphus marmoratus*)[*][**]	**South Polar Skua (*Catharacta maccormicki*)**			Western Gull (*L. occidentalis*)
	Mew Gull (*Larus canus*)				Arctic Tern (*Sterna paradisaea*)
	Horned Puffin (*F. corniculata*)				

[1] Data from Amey *et al.* (2004).

[*] Listed internationally by the International Union for Conservation of Nature and Natural Resources (IUCN)

[**] Listed nationally by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC)

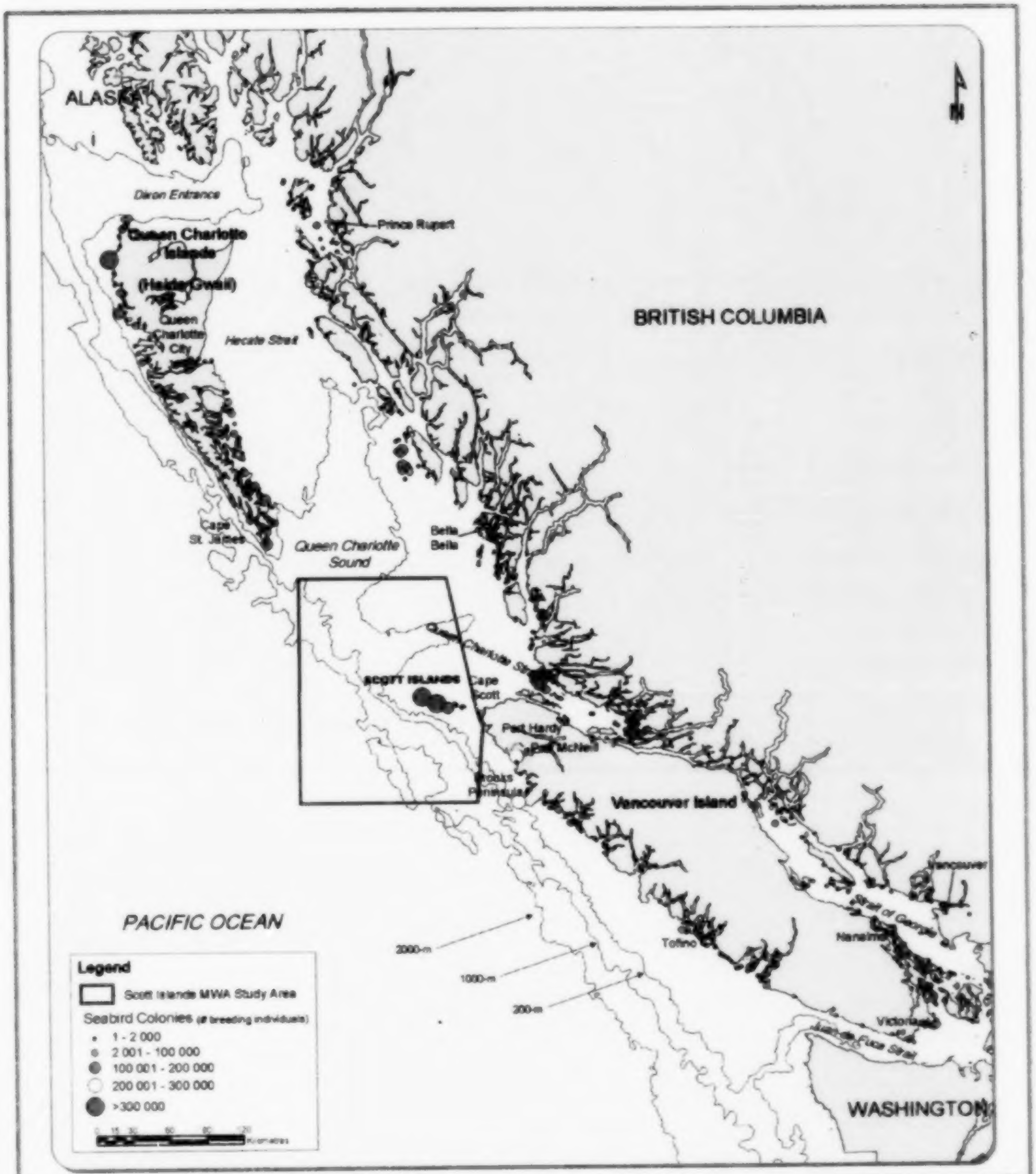


Figure 4-1 Seabird colonies of British Columbia. Data are depicted as total numbers of breeding individuals (not pairs).

Data Source: CWS British Columbia Seabird Colony Inventory 2001

Canada

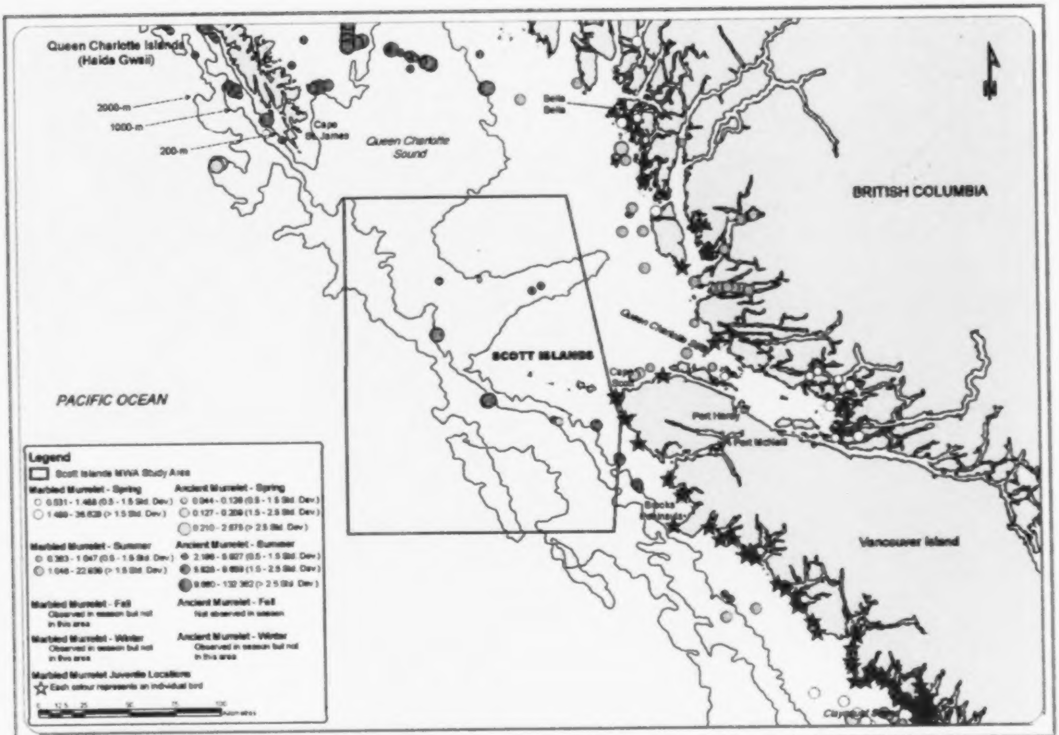

Queen Charlotte Islands (Haida Gwaii)
2000-m
1000-m
200-m
Cape St. James
Queen Charlotte Sound
Bella Bella
BRITISH COLUMBIA
SCOTT ISLANDS
Queen Charlotte Strait
Cape Scott
Port Hardy
Port McNeill
PACIFIC OCEAN
Brooks Peninsula
Vancouver Island
Clayoquot Sound
Legend
Scott Islands MWA Study Area
Marbled Murrelet - Spring
0.531 - 1.468 (0.5 - 1.5 Std. Dev.)
1.469 - 36.628 (> 1.5 Std. Dev.)
Ancient Murrelet - Spring
0.044 - 0.126 (0.5 - 1.5 Std. Dev.)
0.127 - 0.209 (1.5 - 2.5 Std. Dev.)
0.210 - 2.875 (> 2.5 Std. Dev.)
Marbled Murrelet - Summer
0.383 - 1.047 (0.5 - 1.5 Std. Dev.)
1.048 - 22.636 (> 1.5 Std. Dev.)
Ancient Murrelet - Summer
2.186 - 5.827 (0.5 - 1.5 Std. Dev.)
5.828 - 9.659 (1.5 - 2.5 Std. Dev.)
9.660 - 132.382 (> 2.5 Std. Dev.)
Marbled Murrelet - Fall
Observed in season but not in this area
Ancient Murrelet - Fall
Not observed in season
Marbled Murrelet - Winter
Observed in season but not in this area
Ancient Murrelet - Winter
Observed in season but not in this area
Marbled Murrelet Juvenile Locations
Each colour represents an individual bird
0 12.5 25 50 75 100
Kilometres

Figure 4.2 CWS pelagic ship-based survey data (1961-2001) showing seasonal distributions and seasonally averaged densities above mean for two federally listed species, Ancient Murrelet (SARA List: Special Concern) and Marbled Murrelet (SARA List: Threatened) and juvenile Marbled Murrelet telemetry locations, Fall 2002. Seasons: Spring = 1 March - 31 May, Summer = 1 June - 31 July, Fall = 1 August - 31 October, and Winter = 1 November - 28 February. Radio-tagged individuals departed Clayoquot Sound in late July and were detected at marked locations in August and September.

Data source: CWS Pelagic Database. Marbled Murrelet Telemetry Locations
Centre for Wildlife Ecology, Simon Fraser University (Unpublished Data).

Canada

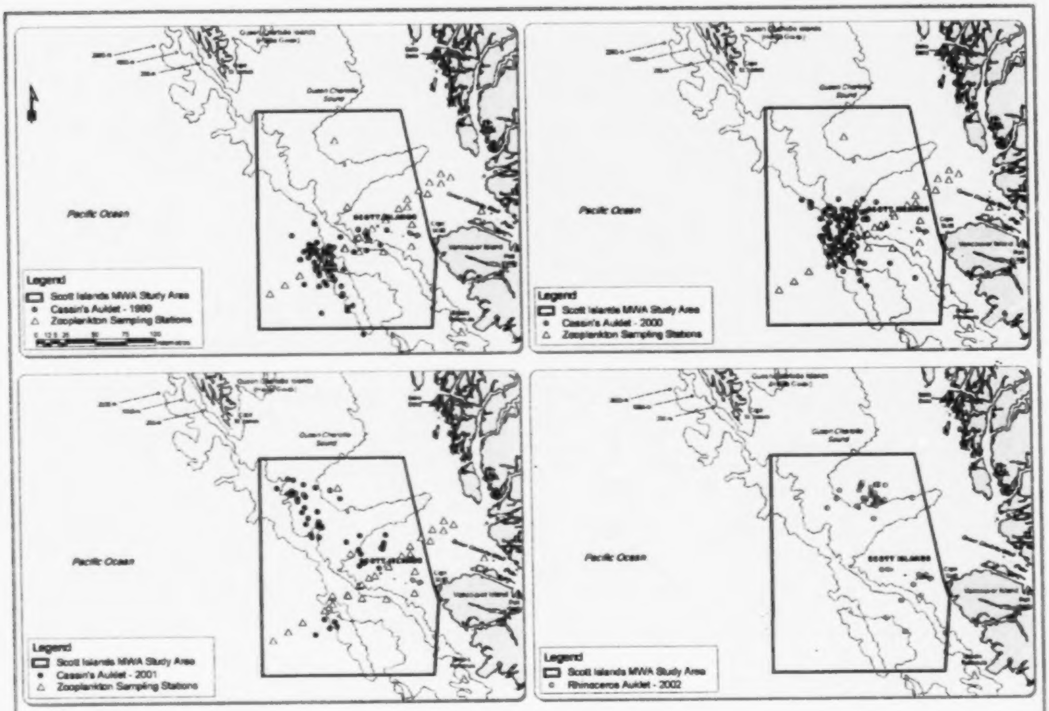


Figure 4-3 Aerial survey telemetry locations for radio-tagged Cassin's Auklets and Rhinoceros Auklets, June 1999-2001 and July 2002. Triangles designate 'Triangle Line' zooplankton sampling stations.

Data source: Telemetry Locations – Boyd et al. (2000), Ryder et al (2001), CWS unpublished data. Zooplankton sampling stations – Institute of Ocean Sciences, Sidney, BC.

Canada

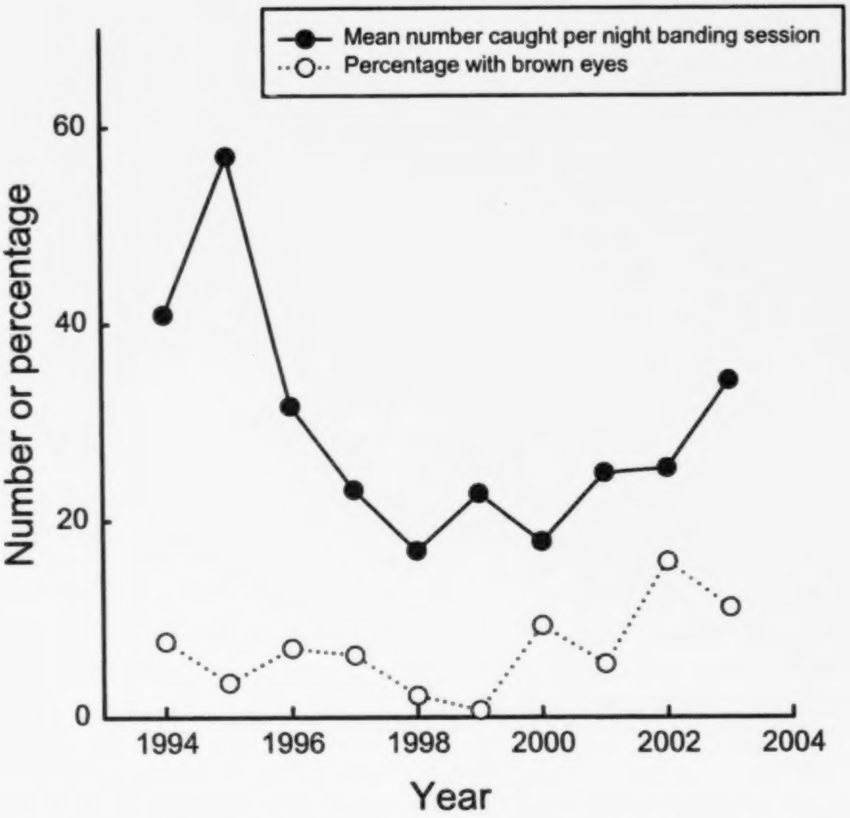


Figure 4-4 Results from a mark and recapture study of Cassin's Auklets at Triangle Island showing number of birds caught and proportion of younger (brown-eyed) birds in the sample.
Data Source: Triangle Island Seabird Research Station Unpublished Data

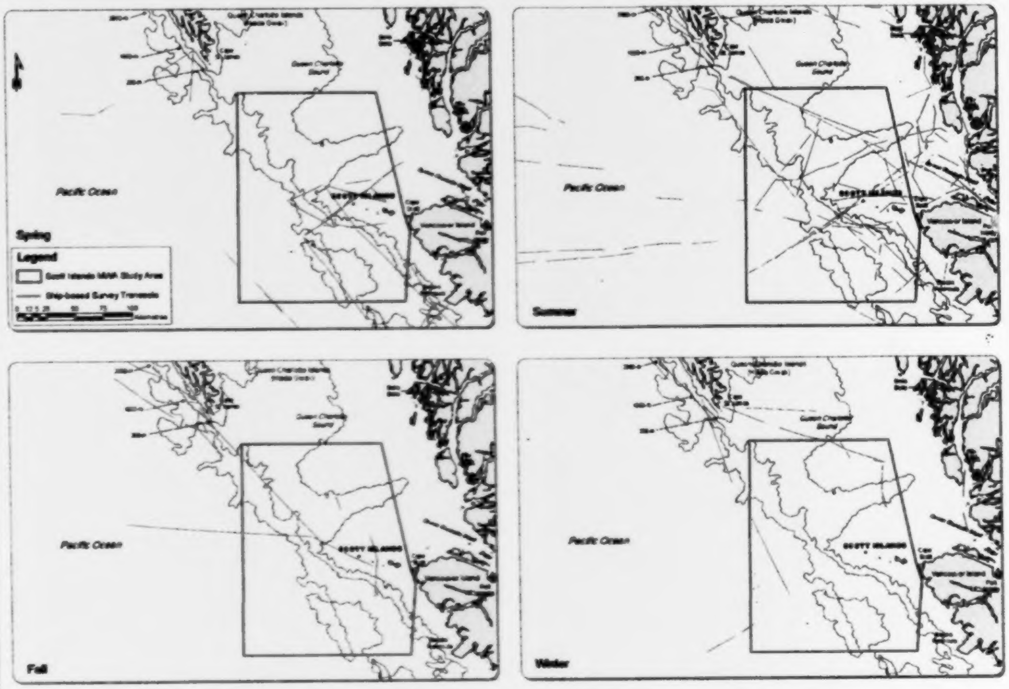


Figure 4-5 CWS pelagic ship-based survey transects (1981-2001) in the vicinity of the Scott Marine Region. Red lines indicated survey routes. Seasons: Spring = 1 March - 31 May, Summer = 1 June - 31 July, Fall = 1 August - 31 October, and Winter = 1 November - 28 February.

Data Source: CWS Pelagic Database (Unpublished data).

Canada

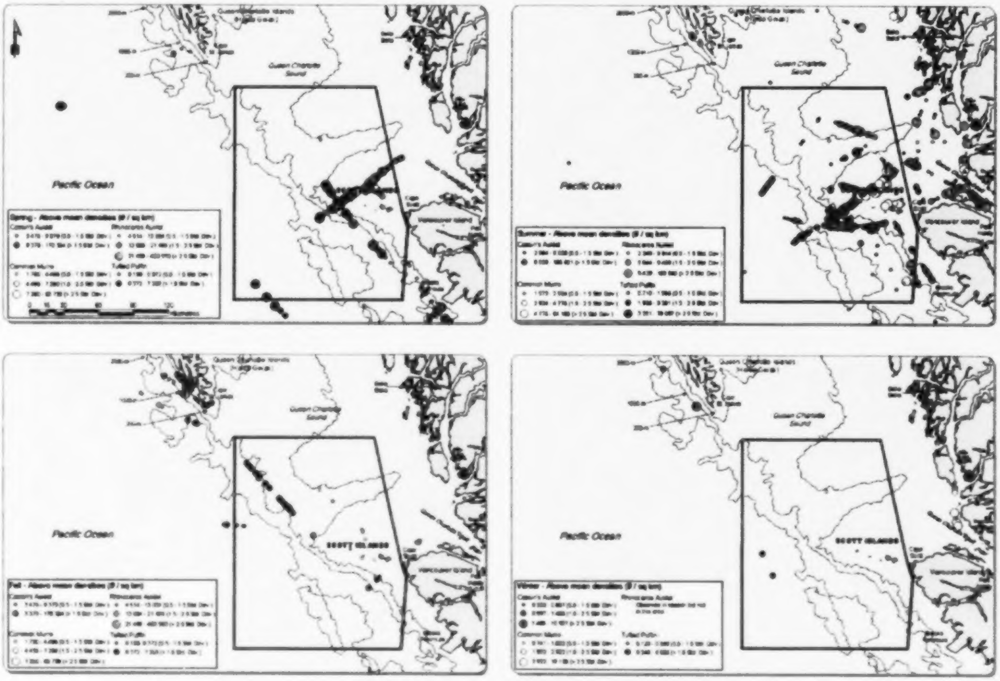
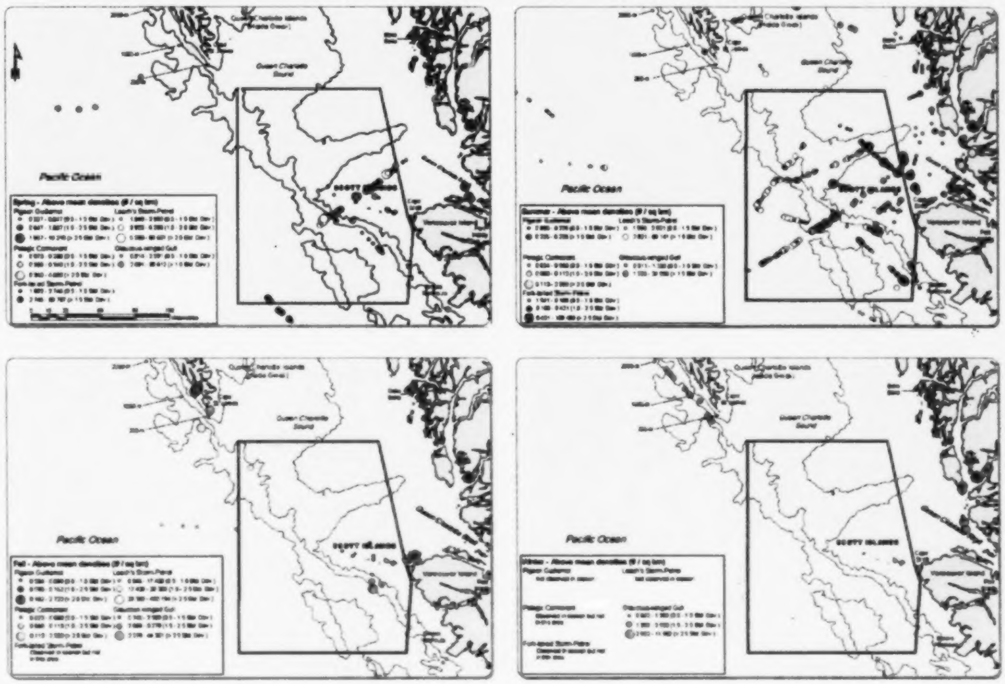

Queen Charlotte Islands
Queen Charlotte Sound
Pacific Ocean
Spring - Above mean densities (# / sq km)
Cassin's Auklet
Rhinoceros Auklet
Common Murre
Tufted Puffin
Summer - Above mean densities (# / sq km)
Vancouver Island
Fall - Above mean densities (# / sq km)
SCOTT ISLANDS
Winter - Above mean densities (# / sq km)

Figure 4-6 CWS pelagic ship-based survey data (1981-2001) showing seasonal distributions and seasonally averaged densities above the regional mean for Triangle Island focal breeding alcids. Seasons: Spring = 1 March - 31 May, Summer = 1 June - 31 July, Fall = 1 August - 31 October, and Winter = 1 November - 28 February

Data Source: CWS Pelagic Database (Unpublished data)

Canada



Pacific Ocean
Queen Charlotte Sound
Vancouver Island
SCOTT ISLANDS
Spring - Above mean densities (# / sq km)
Summer - Above mean densities (# / sq km)
Fall - Above mean densities (# / sq km)
Winter - Above mean densities (# / sq km)
Pigeon Guillemot
Leach's Storm-Petrel
Pelagic Cormorant
Glaucous-winged Gull
Fork-tailed Storm-Petrel

Figure 4-7 CWS pelagic ship-based survey data (1981-2001) showing seasonal distributions and seasonally averaged densities above the regional mean for remaining breeding seabird species at Triangle Island. Seasons: Spring = 1 March - 31 May, Summer = 1 June - 31 July, Fall = 1 August - 31 October, and Winter = 1 November - 28 February

Data Source: CWS Pelagic Database (Unpublished data)

Canada

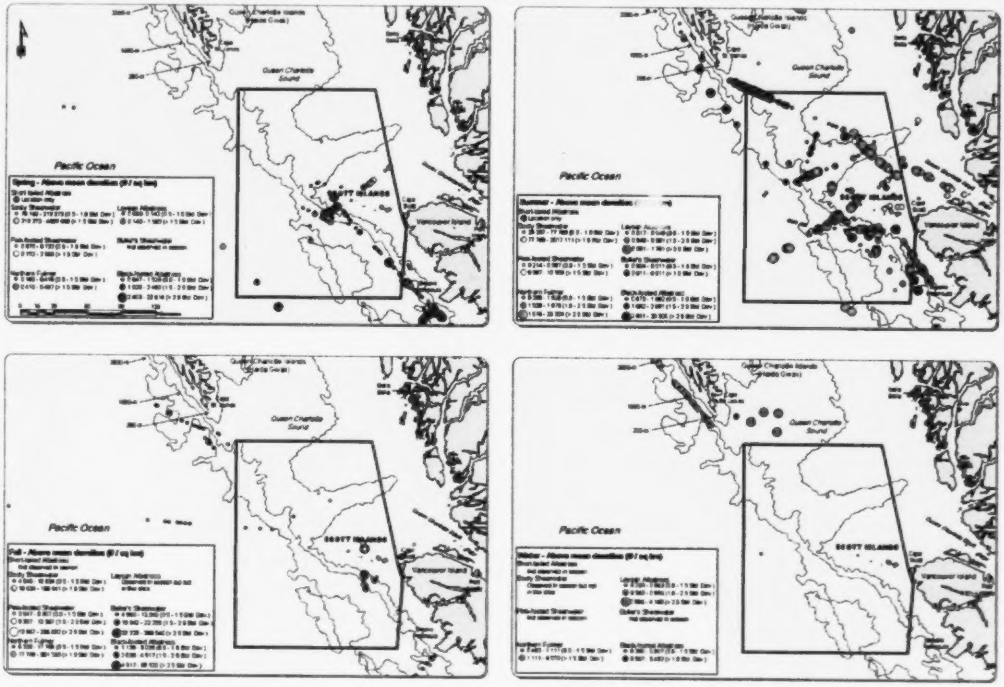


Figure 4-8 CWS pelagic ship-based survey data (1981-2001) showing seasonal distributions and seasonally averaged densities above the regional mean for non-breeders. Seasons: Spring = 1 March - 31 May, Summer = 1 June - 31 July, Fall = 1 August - 31 October, and Winter = 1 November - 28 February.

Data Source: CWS Pelagic Database (Unpublished data).

Canada

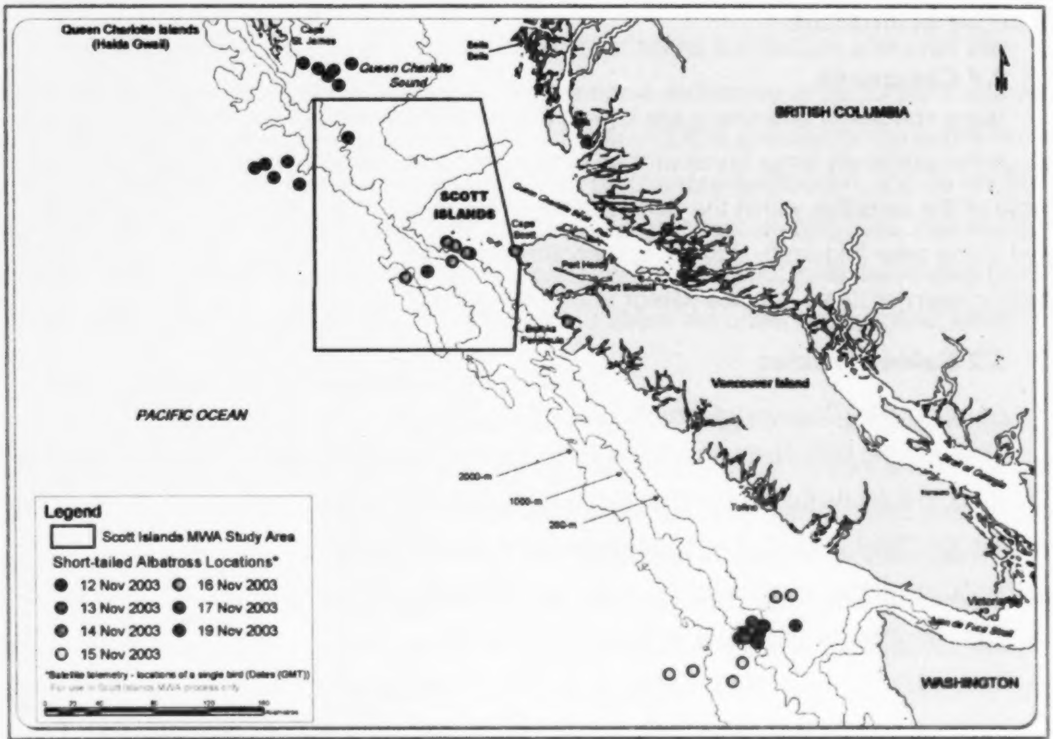


Figure 4-8 Satellite telemetry locations of a hatch-year Short-tailed Albatross. This individual fledged from Torishima, Japan in May 2003 and was captured and fitted with a satellite transmitter on August 12, 2003 at Seguam Pass in the Aleutian Islands. Short-tailed Albatross are listed as Threatened by COSEWIC (Assessed 2003) and Vulnerable by the IUCN (Assessed 2003).

Data Source: Greg Balogh (U.S. Fish and Wildlife Service) and Rob Suryan (Oregon State University) - unpublished data

Canada

5. Marine Mammals

5.1 Cetaceans

Many species of cetaceans are known to inhabit the waters of the Northeast Pacific. Although the extremely large home ranges of most of these animals preclude any meaningful estimate of the densities within the Scott Islands MWA study area, cetaceans are frequently sighted in the area (Figure 5-1) and it is likely that the MWA Study Area provides good foraging habitat for many of these species (Gregr and Trites 2001).

5.2 Baleen Whales

Blue Whale (Balaenoptera musculus)

Although the U.S. National Marine Fisheries Service (NMFS) recognizes a central North Pacific stock that feeds during summer in the Gulf of Alaska, virtually nothing is known about this population (SAR 2000a). It is hypothesized that this population is separate from eastern North Pacific stock that forages off the coast of California in the summer and fall, and that it may migrate to offshore waters north of Hawaii in winter.

The largest of the baleen whales, blue whales feed almost exclusively on euphausiids (krill). However, as most catches of this species by local whaling stations occurred near the shelf break (Gregr and Trites 2001), and blue whales have been sighted in the area (BCCSN 2003) the Scott Islands MWA study area may represent valuable habitat.

Fin Whale (Balaenoptera physalus)

This species typically forages closer to shore than does the blue whale. The diet of the Fin Whale is similar to that of the Blue Whale, although it has been observed to supplement its euphausiid intake with significant proportions of copepods, pelagic fish, and small squid (Flinn *et al.* 2002).

Based on historical whaling data, the entire eastern North Pacific population in the early 1970's was estimated at between 14,620 - 18,630 animals, of which only a small fraction would use

British Columbian waters (SAR 2000b). Although historically harvested in substantial numbers by the British Columbia whaling industry (Gregr *et al.* 2000), the species became less abundant inshore (probably as a result of biased capture of inshore individuals). Fin whales have been sighted in the Scott Islands MWA study area (BCCSN 2003).

Sei Whale (Balaenoptera borealis)

This species is known to have a predominantly offshore distribution, and what little survey evidence there is suggests that the BC population is extremely small (Gregr and Deecke 2002). The NMFS report contained an estimate of 7,260 - 12,620 animals for the entire North Pacific, and noted that this species has a predominantly offshore distribution, and no known association with coastal features (SAR 2000c). Based on historical whaling data, individuals likely have used the Scott Islands MWA study area (Gregr *et al.* 2000), and Sei whales have been sighted in the area (BCCSN 2003). However, numbers are undoubtedly rather small.

Minke Whale (Balaenoptera acutorostrata)

A small baleen whale, the minke whale occurs in both inshore and offshore habitats. Local populations are probably migratory, spending the winter months in more tropical waters. Minke whale diet for southern British Columbia was estimated to consist of approximately equal proportions of euphausiids, copepods, herring, and sandlance (Trites and Heise 1996).

An incomplete survey of the Alaskan population yielded an abundance estimate of 936 animals (SAR 2001), while the most recent estimate of the California/ Washington/Oregon stock is 631. Although population estimates for this species have not been carried out in British Columbia, it is likely that it occurs here in similar densities, given its presence both in Alaska and to the south (Gregr 2003). Minke whales have been sighted in the Scott Islands MWA study area (BCCSN 2003).

Humpback Whale (Megaptera novaeangliae)

A cosmopolitan and easily recognizable large cetacean, the humpback whale feeds mainly on euphausiids, but supplements this diet with copepods and small fish. The entire eastern North Pacific population is estimated to be 4,005 animals, of which one third may form the nearest southeastern Alaska population (Calambokidis *et al.* 1997; Gregr 2003). Only some fraction of this population would use BC waters. However, over 900 animals have been photo-identified in BC waters (Gregr 2003). Migratory behaviour of BC humpbacks is complex, with individuals known to migrate to breeding grounds in Mexico, Hawaii, and the breeding island of Ogasawara off Japan (Calambokidis *et al.* 2001). Although this animal tends to have a nearshore distribution, making extensive use of coastal habitats, they also use more pelagic regions to feed (J. Ford, pers. comm.). In addition, the Scott Islands MWA study area likely includes sections of humpback migratory pathways (E. Gregr, pers. comm.). Humpback whales are commonly sighted in the area, and sometimes occur in large groups (BCCSN 2003; Simon Fraser University, Dept. of Biol. Sciences, unpubl. documents).

Grey Whale (Eschrichtius robustus)

The grey whale is generally considered to be a benthic feeder, whose diet is dominated by amphipods. Summer-residents in BC are known to feed on other benthic prey, including ghost-shrimp and small clams (Dunham and Duffus 2001) as well as planktonic invertebrates such as mysid shrimp (Dunham and Duffus 2002).

The eastern North Pacific population is currently estimated at 26,635 (SAR 2002). The majority of these animals feed in the Bering Sea during summer, but migratory routes to and from calving grounds in the Gulf of California bring much of the population through the Scott Islands MWA study area between January and the end of May. In addition, some summer residents are known to remain in British Columbia waters (Deecke 2002). Known feeding sites include northwest Vancouver Island, which overlaps the Marine Area. Grey whale are sighted consistently by researchers on Triangle Island (Simon Fraser University, Dept. of Biol. Sciences, unpubl. documents). Figure 5-2 illustrates known migration and feeding sites for grey whales.

5.3 Toothed Whales

Sperm Whale (Physeter macrocephalus)

The largest of the toothed whales, these deep-water cetaceans feed primarily on large squid, but smaller squid and various squid species are also eaten (Flinn *et al.* 2002). Males and females tend to segregate spatially, with males remaining closer to shore while females move further offshore (Gregr *et al.* 2000).

The most recent estimate for the entire eastern temperate North Pacific was 39,200, although this is considered to be unreliable (SAR 1998). This species comprised a substantial proportion of the total catch from British Columbia whaling stations, and most were taken in deeper waters at or beyond the shelf break (Gregr *et al.* 2000). Individuals or small groups of sperm whales are seen with some frequency in the Scott Islands MWA study area (BCCSN 2003).

Killer Whale (Orcinus orca)

Killer Whales are found in nearly all the world's oceans in a wide variety of habitats. There are four distinct populations in British Columbia: northern residents, southern residents, transients, and the offshore group. Members of all four populations have been sighted within the Scott Islands MWA study area (J. Ford, pers. comm.). Both resident populations, as well as the transients, are listed as 'Threatened' by COSEWIC (1999) and are protected under the Species at Risk Act (SARA Public Registry), while the offshore group is a Species at Risk population of 'Special Concern'. Residents and offshore killer whales are fish-eating (chiefly salmon, in the case of residents), while the behaviourally and morphologically distinct transient group preys on marine mammals, including sea lions. The northern resident population is known to comprise 206 individuals, as of 2002 (J. Ford, pers. comm.). These residents occur off north Vancouver Island and southeast Alaska and have been sighted within the Scott Islands MWA study area (Figure 5-1). The offshore group is thought to feed in the vicinity of the continental shelf. Although very little is known about the offshore population, a pod of 8-9 offshore killer whales was sighted southeast of Cox Island in 2001 (G. Ellis, pers. comm.). Baird (1999) states that about 200 individuals from this population have been identified along the west coast of North America, and that individuals move freely between Oregon and Alaska. The transient population is estimated at 219 individuals (Trites and Barrett-Lennard 2001). Due to the importance of the area for sea lions, a principal prey item for transients (Baird 1999), it is likely that this group uses the Scott Islands MWA study area extensively (J. Ford, pers. comm.). Pods of Killer Whales are commonly seen in the vicinity of Triangle Island, and there are anecdotal reports of animals attacking Steller sea lions (Simon Fraser University, Dept. of Biol. Sciences, unpubl. documents).

Other odontocetes

Other species which are known to use the Scott Islands MWA study area include Pacific White-sided Dolphin (*Lagenorhyncus obliquidens*), Dall's porpoise (*Phocoenoides dalli*), Harbour porpoise (*Phocoena phocoena*), and Baird's Beaked Whale (*Beradius bairdii*) (BCCSN 2003).

White-sided Dolphins may be the most abundant cetacean in the coastal waters of British Columbia (Heise 1996). Around Vancouver Island, abundance is thought to be positively correlated to water temperature, as well as abundance of their principal forage fish prey (Morton 2000). Dall's porpoise is widely distributed in the eastern North Pacific, and are present year-round in the region. Diet consists of a diversity of small fish and squid, and varies widely according to local availability (Houck and Jefferson 1999). Harbour porpoise primarily frequent inshore coastal waters, where they feed on small squid and schooling fish. Although known to occur year-round in southern British Columbia, densities are thought to decrease with increasing latitude (Gregr 2003).

Little is known about Baird's beaked whale, or indeed any of the species of beaked whales whose ranges include the offshore waters of British Columbia. The Baird's beaked whale is a medium-sized (~10m) whale that prefers the deep offshore waters of the North Pacific, where it travels in small groups ranging from 6-30 members. They feed primarily on squid, although they also eat various other fish and invertebrate species (Lundrigan and Myers 2000). Beaked whales, particularly the Cuvier's beaked whale (*Ziphius cavirostris*), may be negatively impacted by sonar and seismic testing activities (see section 8.4.3).

5.4 Cetacean Habitat Mapping

Gregr and Trites (2001) used 20 years of whaling location, time, and species data to build a model which predicted whale presence from 6 positional and oceanographic variables. The intent of the model was to identify important habitat for five cetacean species (Blue, Fin, Sei, Humpback, and Sperm whales).

Results indicate that a large area off the northwest coast of Vancouver Island, extending north towards the Queen Charlottes and about one third of the way down Vancouver Island, represents quality cetacean habitat for many of the species (see Figure 5-3 for an example). The results were interpreted in relation to spatial and temporal distributions of zooplankton (Mackas 1992, Mackas and Galbraith 1992), suggesting that the area to the northwest of Vancouver Island is an area of high zooplankton productivity or entrainment, by virtue of the convergence of currents, bathymetry, and the input of fresh water. There is a considerable degree of overlap between important whale habitat and the MWA Study Area (Figure 5-3), indicating that it represents a potential high-value area for many baleen whale species.

5.5 Pinnipeds

Steller sea lions and harbour seals are the principal pinniped species found in the region, although California sea lions (*Zalophus californicus*) are also known to utilize the area in summer, and are frequently abundant at Triangle Island haulouts (Simon Fraser University, Dept. of Biol. Sciences, unpubl. documents). Small groups of Elephant seals (*Mirounga angustirostris*) are also known to use haulouts at Triangle Island (Simon Fraser University, Dept. of Biol. Sciences, unpubl. documents).

Steller Sea Lion

The Steller sea lion is the largest member of the Ottaridae family. Due in part to their polygynous mating system, sea lion exhibits considerable sexual dimorphism. The largest adult males can weigh over 1100 kg, while females typically weigh between 200-300 kg. Breeding takes place in spring to early July in a small number of established rookeries (COSEWIC 2003b). During the non-breeding season (and year-round for non-breeders), sea lions use a larger set of established haulout locations. Sea lions eat a wide variety of fish and invertebrate species, but preferred prey appear to be small to medium-sized schooling fishes (e.g. herring, sandlance) and bottom fishes such as sole and flounder (COSEWIC 2003b).

The Scott Islands MWA study area represents a critical region for Steller sea lions in British Columbia, as the majority of the breeding population of this species is present in rookeries either within or near the defined area (Figure 5-4). The British Columbia population is currently estimated at 18,400 - 19,700 individuals, or approximately 16% of the world population (Olesiuk and Trites 2003). Sea lions breed at four of locations on the Scott Islands: Maggot (a small island north of Beresford), Beresford, Sartine, and Triangle Islands. In a 2002 census, the total number of non-pups at these locations was estimated at 3866. Three of these locations produced significant numbers of pups in 2002: Triangle Island (2199), Maggot Island (76), and Sartine Island (146). The Triangle Island rookery currently represents the largest colony in Canada and the second largest in the world.

Additionally, there is a rookery at Cape St. James at the southern tip of Haida Gwaii (Figure 5-4). At 982 non-pup individuals (635 pups) in 2002, this rookery is the second largest in Canada, and the 6th largest in the world. Although not within the Scott Islands MWA study area, known foraging ranges in both the breeding season (60 km) and the non-breeding season (200 km) suggest that Steller sea lions breeding at Cape St. James could be utilizing the study area at all times of the year (Merrick and Loughlin 1997).

Other important haulout sites in the region include Virgin, Pearl, and Gosling Rocks east of the Scott Marine area on the mid-coast, and Barrier and Solander Islands on northwest Vancouver Island (Figure 5-4). Individuals using these haulout sites may also be using the Scott Islands MWA study area for foraging.

Harbour Seal

The Pacific harbour seal is a small pinniped: adults attain lengths of 1.2- 1.6 m and weigh 60-80 kg. The breeding season varies from early spring to late summer, depending on location, but lasts only 2 months. Unlike sea lions, harbour seals do not congregate at rookeries to breed. Instead, pups are born on sandbars or tidal reefs throughout their range. Harbour seals feed on a wide variety of small fishes that occur in shallow water around reefs, such as rockfish, sculpins, and smelt (Olesiuk 1999).

The total abundance of harbour seals in British Columbia is currently estimated at 108, 000 individuals, based on an extrapolation of the observed density of seals in surveyed areas to the entire province and on the relative distribution of historical bounty kills (Olesiuk 1999). Population growth rates had been operating near the theoretical limits of the species since control programs and commercial harvests ceased in 1970, but growth rates began to slow in the early 1990's and the population now appears to have stabilized (Olesiuk 1999; Gregr 2003). Within the Scott Islands MWA study area, there are a total of 6 known haulout sites, all located on Lanz and Cox Islands. Based on 1996 counts at haulouts and current estimates of the proportion of seals at sea at the time of the survey (65%), approximately 130 seals use these sites. Additionally, harbour seals counted at three haulout sites on the northwest coast of Vancouver Island (approximately 98 individuals) may be using the Scott Islands MWA study area for foraging, as harbour seals breeding in outer coastal regions elsewhere in the world have been known to travel as much as 50 km from haulout sites (Olesiuk 1999; P. Olesiuk pers. comm.).

5.6 Steller Sea Lion Habitat Mapping

Researchers at University of British Columbia have developed a spatially explicit model to quantitatively characterize physical habitat conditions surrounding Steller sea lion rookeries and haulout sites. Based on these conditions, they predict probable high-quality habitat for sea lions in British Columbia (Ban *et al.* in prep). Oceanographic conditions associated with these sites included high tidal speeds, low surface temperatures, and shallower waters. These were interpreted as reflecting high ocean productivity. Near-shore conditions appeared to predict haulout locations more effectively than conditions at greater distances. Portions of the Scott Islands MWA study area, including the waters surrounding Triangle Island and those directly northwest of Cape Scott, were identified by the model, and may represent habitat critical to the survival of Steller sea lions (Figure 5-5).

5.7 Sea Otters

Weighing 45 kg and reaching 150 cm in length, the sea otter is among the smallest of marine mammals. Nearly extirpated due to intense exploitation in the fur trade during the 18th and 19th centuries, the species was protected in 1911. The world population is estimated at about 150, 000 animals, although sea otters currently occupy only about half of the historical range (Watson et al. 1996). Females produce approximately one pup a year, usually in spring or early summer. Sea otters feed mainly on shellfish and sea urchins.

Although extirpated from BC following intensive harvesting for the fur trade in the 19th century, sea otters were re-introduced between 1969 and 1972. Since that time, populations have increased at a rate of 18.6 % annually. A 1998 census estimated that there were approximately 2000 sea otters along the west coast of Vancouver Island between Cape Scott and Estevan Point, as well as an additional 500 animals off the central coast of BC (Watson 2000). In British Columbia, sea otters generally occur along stretches of exposed coastline characterized by complex rocky shorelines with small islets and offshore rocky reefs. Throughout their range in the North Pacific, sea otters occur in shallow coastal waters not generally deeper than 40 m and seldom range beyond 1-2 km of shore (Riedman and Estes 1990). Within the Scott Islands MWA study area, sea otters utilize the coastal regions from Cape Scott to the point north of San Josef Bay. Due to logistical constraints, there has been no formal survey for this species in the Scott Islands (L. Nichol, pers. comm.). However, individual sea otters are periodically sighted foraging in the waters surrounding Triangle Island and, on two occasions, female with young were also sighted (Simon Fraser University, Dept. of Biol. Sciences, unpubl. documents). Based on what is known of sea otter habitat preferences, the waters surrounding the Scott Islands likely represent high-quality habitat for this species. As its range in BC continues to expand, it is expected that these areas will support healthy populations of sea otters in the future (L. Nichol, pers. comm.).

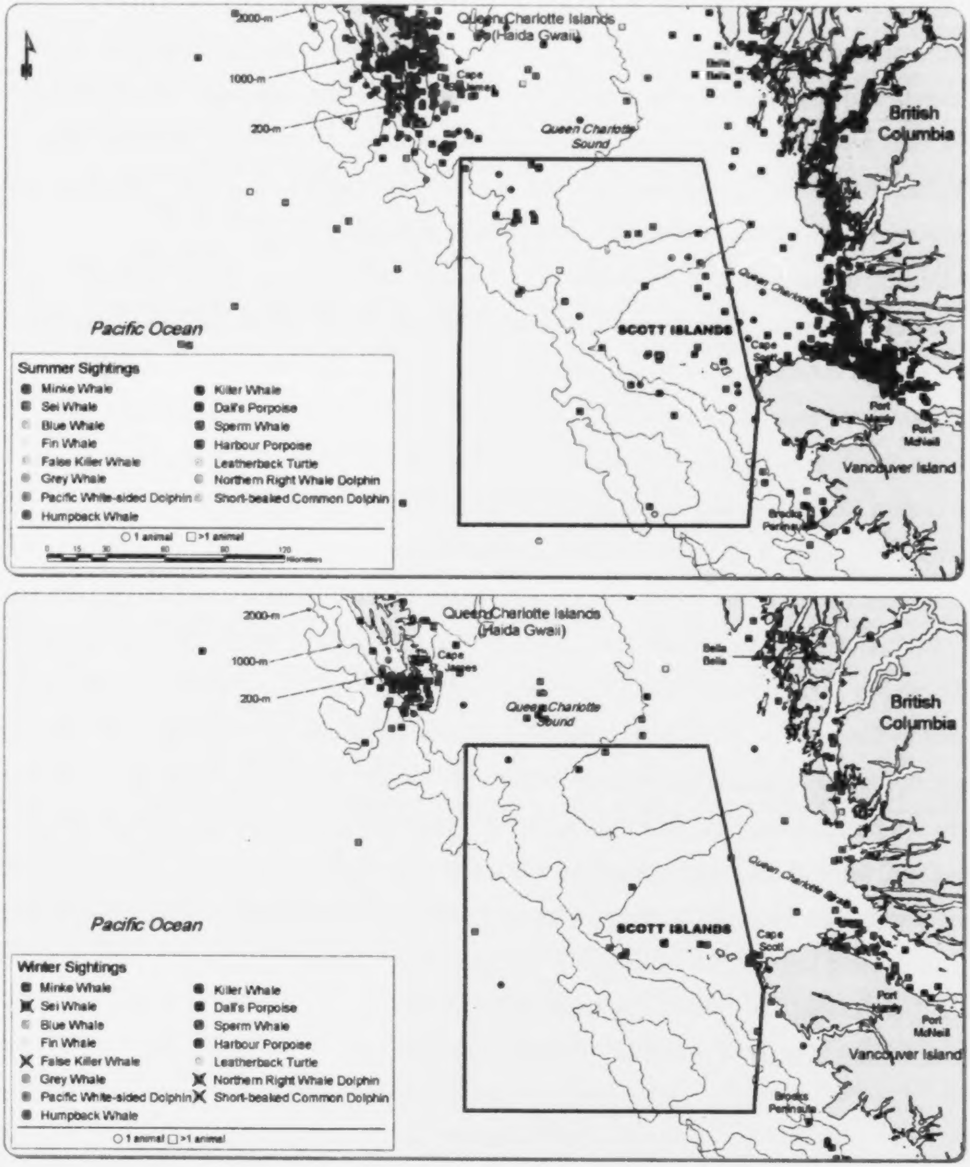


Figure 5-1 Cetacean sightings (1980-2003) in the vicinity of the Scott Islands MWA Study Area. Seasons: Summer = 1 May - 30 September and Winter = 1 October - 30 April.

Data Source: British Columbia Cetacean Sightings Network

Canada

Produced by CWS GIS Unit
Date: 25 May 2004

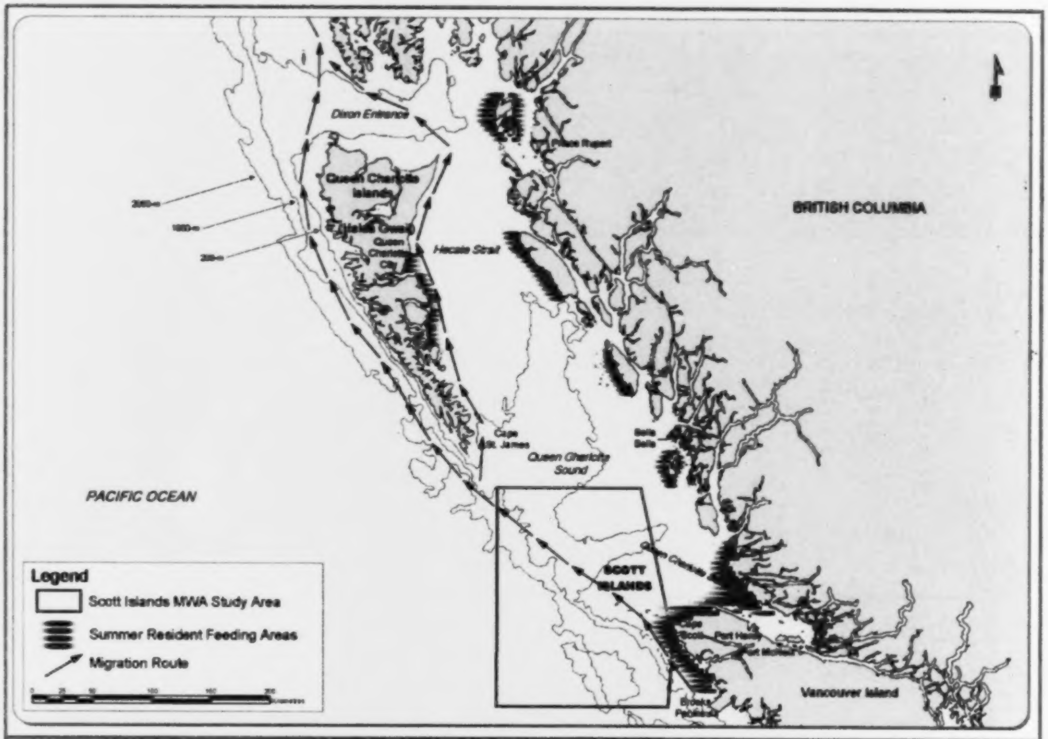


Figure 5-2 Grey Whale feeding and migratory routes in the vicinity of the Scott Islands MWA Study Area. Shaded feeding areas are thought to be used predominantly by the resident population.

Data Source: V.B. Deecke COSEWIC Status Report, submitted

Canadä

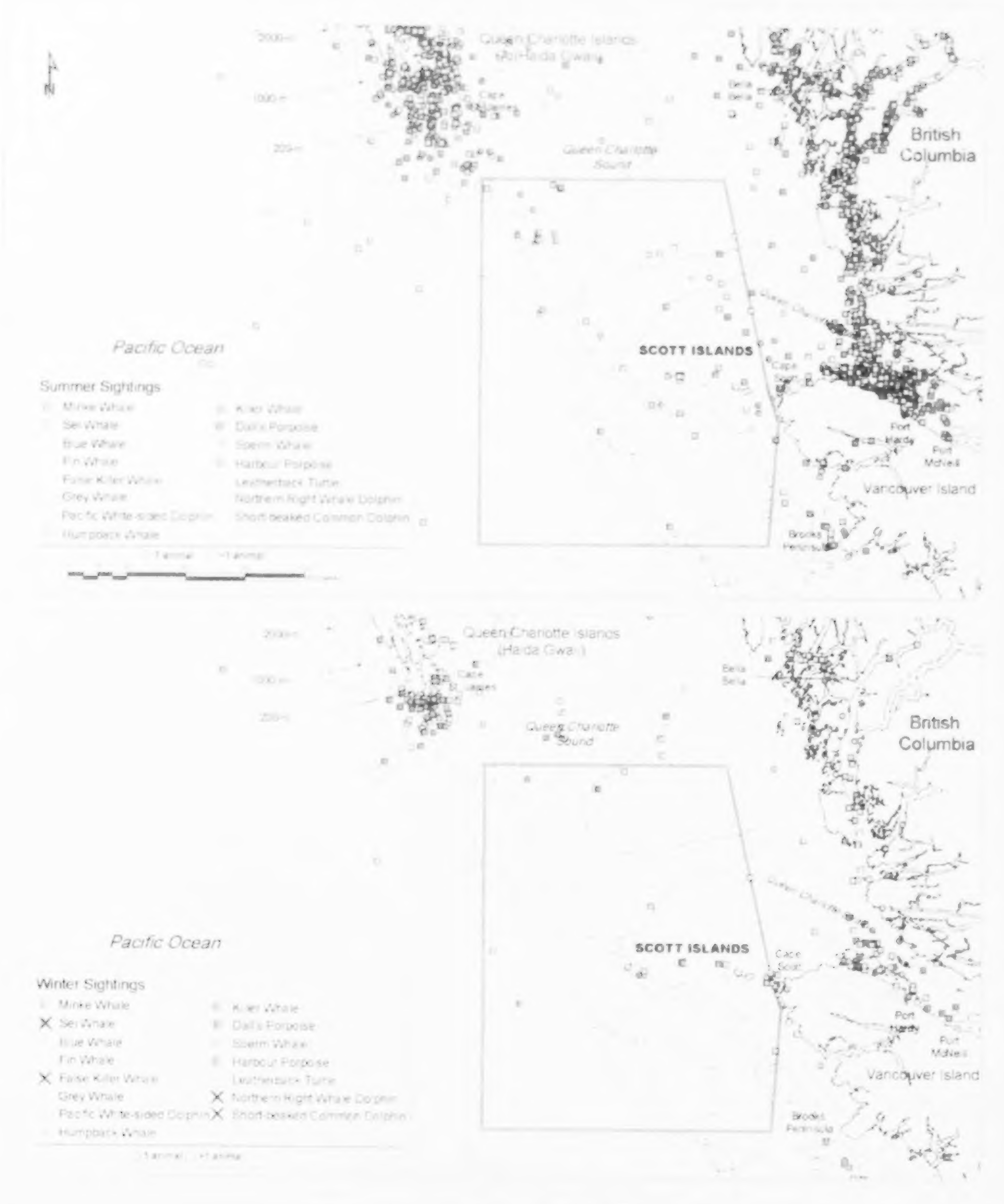


Figure 5-1 Cetacean sightings (1960-2003) in the vicinity of the Scott Islands MWA Study Area. Seasons: Summer = 1 May - 30 September and Winter = 1 October - 30 April.

Data Source: British Columbia Cetacean Sightings Network

Canada

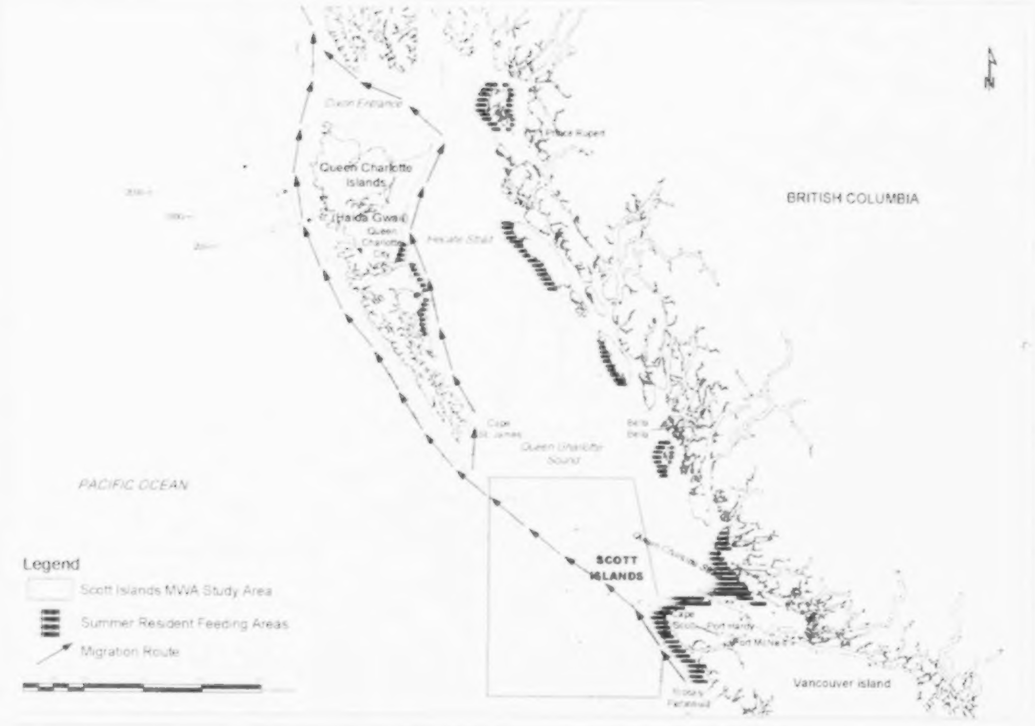


Figure 5.2 Grey Whale feeding and migratory routes in the vicinity of the Scott Islands MWA Study Area. Shaded feeding areas are thought to be used predominantly by the resident population.

Data Source: V.B. Deecke COSEWIC Status Report, submitted.

Canada

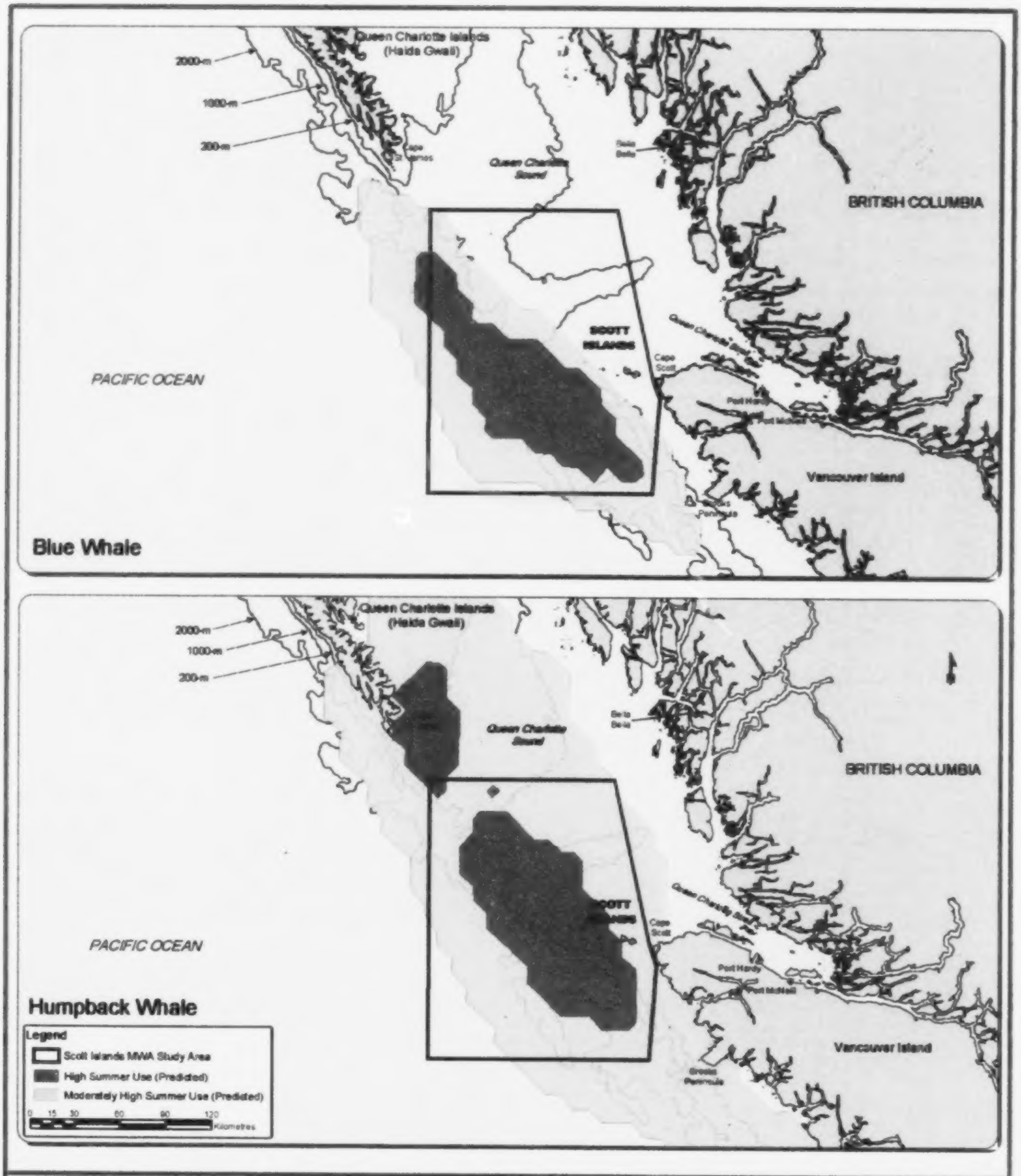


Figure 5-3 Probability predictions for blue (n = 249) and humpback (n = 598) whales based on positional information and oceanographic data of whales killed between 1948 -1967. Shaded areas represent a moderate to high probability of summer whale occurrence, while non-shaded areas represent a low probability.

Data source: Gregr & Trites 2001

Produced by CWS GIS Unit
Date: 11 May 2004

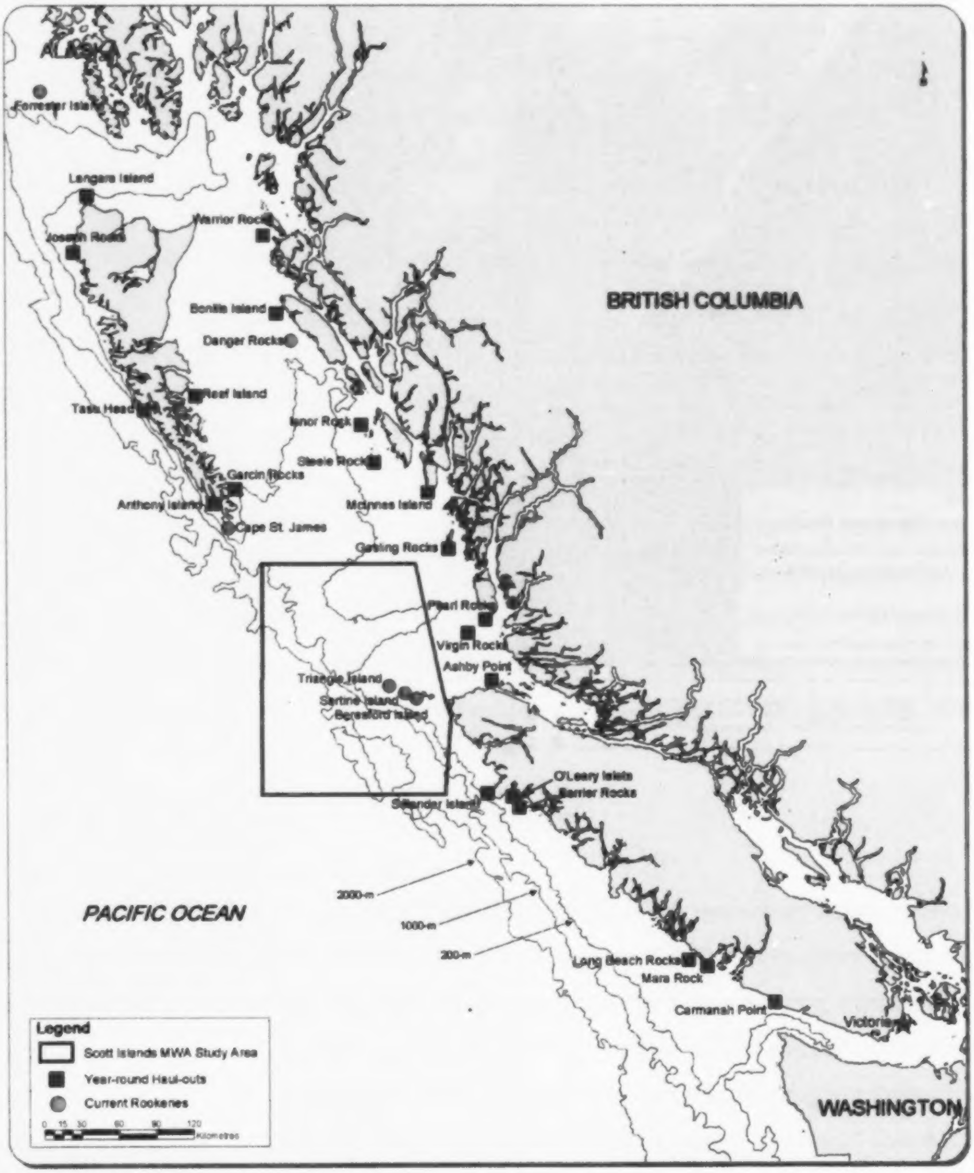


Figure 5-4 Steller Sea Lion rookeries and year-round haulout locations in BC

Data Source: Olesiuk & Trites COSEWIC Status Report, submitted.

Canada

Produced by: CWS GIS Unit
Date: 7 May 2004

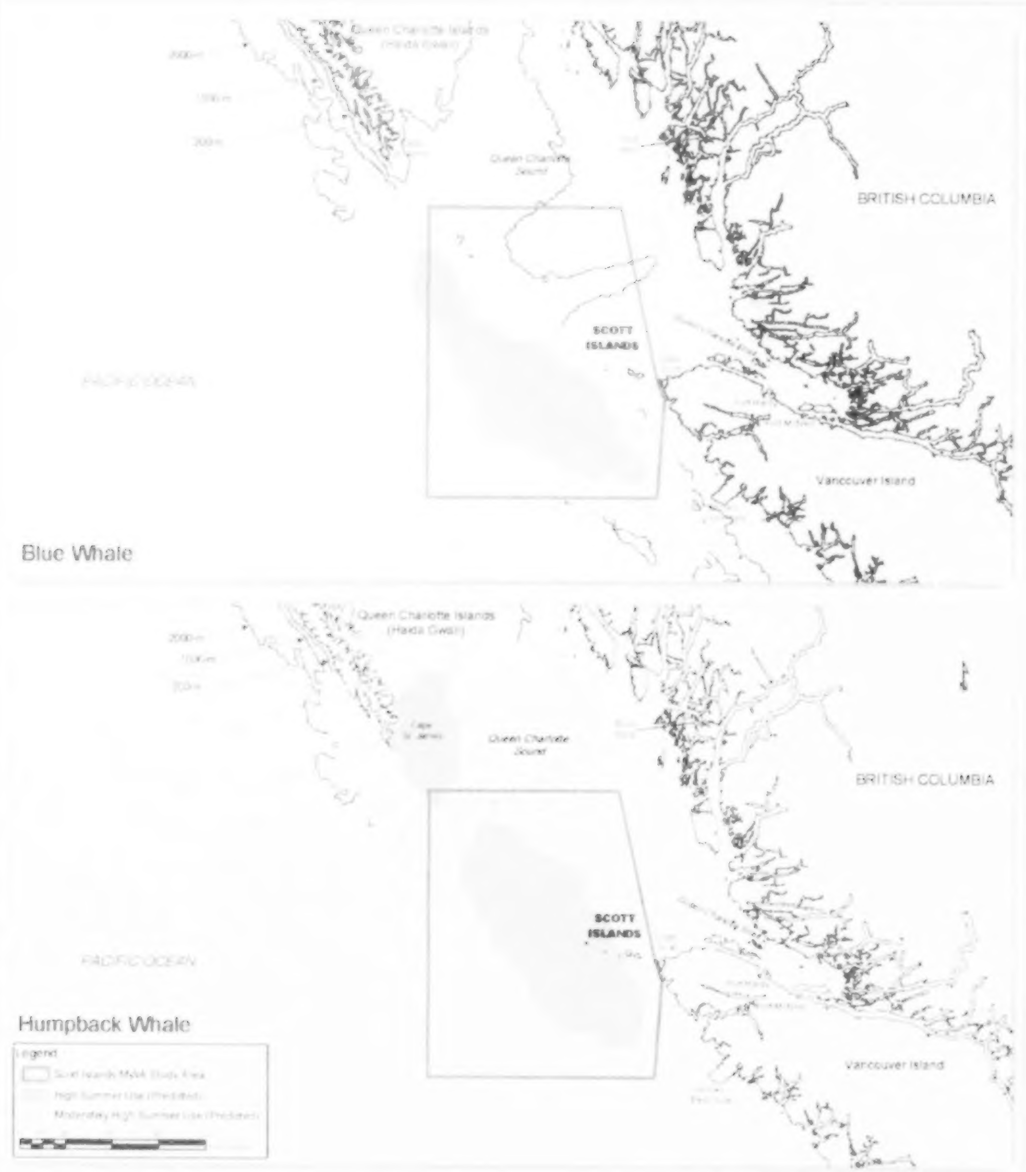


Figure 5-3 Probability predictions for blue (n = 249) and humpback (n = 598) whales based on positional information and oceanographic data of whales killed between 1948 -1967. Shaded areas represent a moderate to high probability of summer whale occurrence, while non-shaded areas represent a low probability.

Data source: Gregr & Trites 2001

Canada

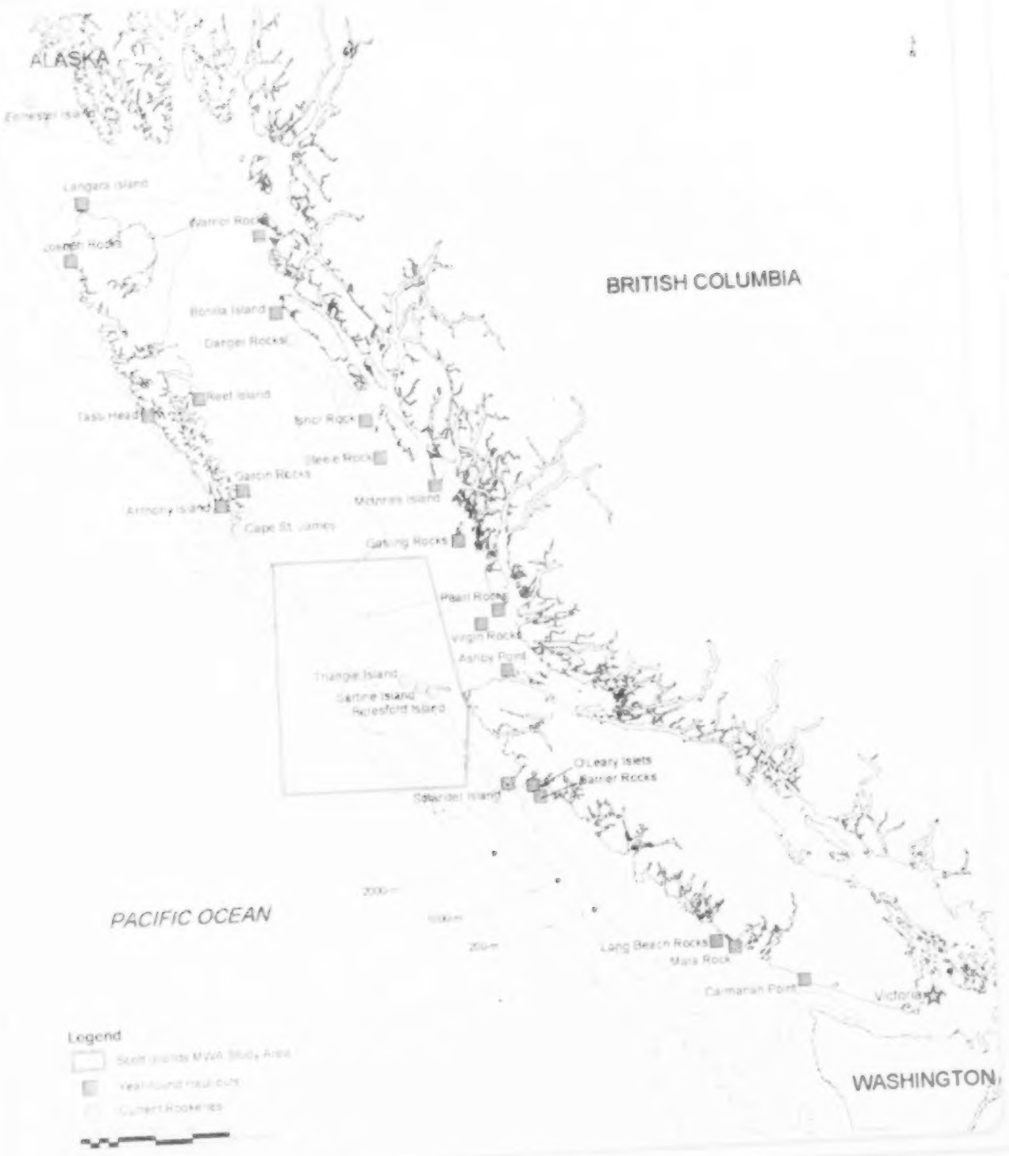
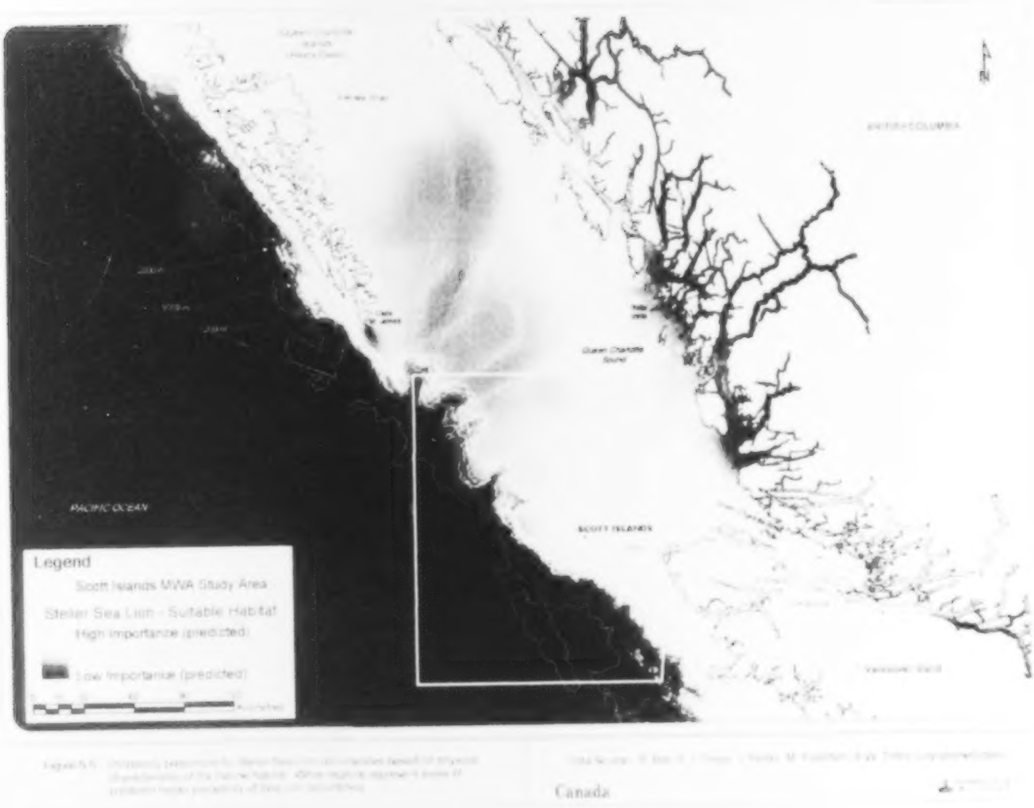


Figure 5-4 Steller Sea Lion rookeries and year-round haulout locations in BC

Data Source: Olesiuk & Trites COSEWIC Status Report, submitted

Canada


Queen Charlotte Islands
(Haida Gwaii)
Hecate Strait
BRITISH COLUMBIA
200m
1000m
Cape St. James
Queen Charlotte Sound
PACIFIC OCEAN
SCOTT ISLANDS
Vancouver Island
Legend
Scott Islands MWA Study Area
Steller Sea Lion - Suitable Habitat
High importance (predicted)
Low importance (predicted)
Kilometres
Canada

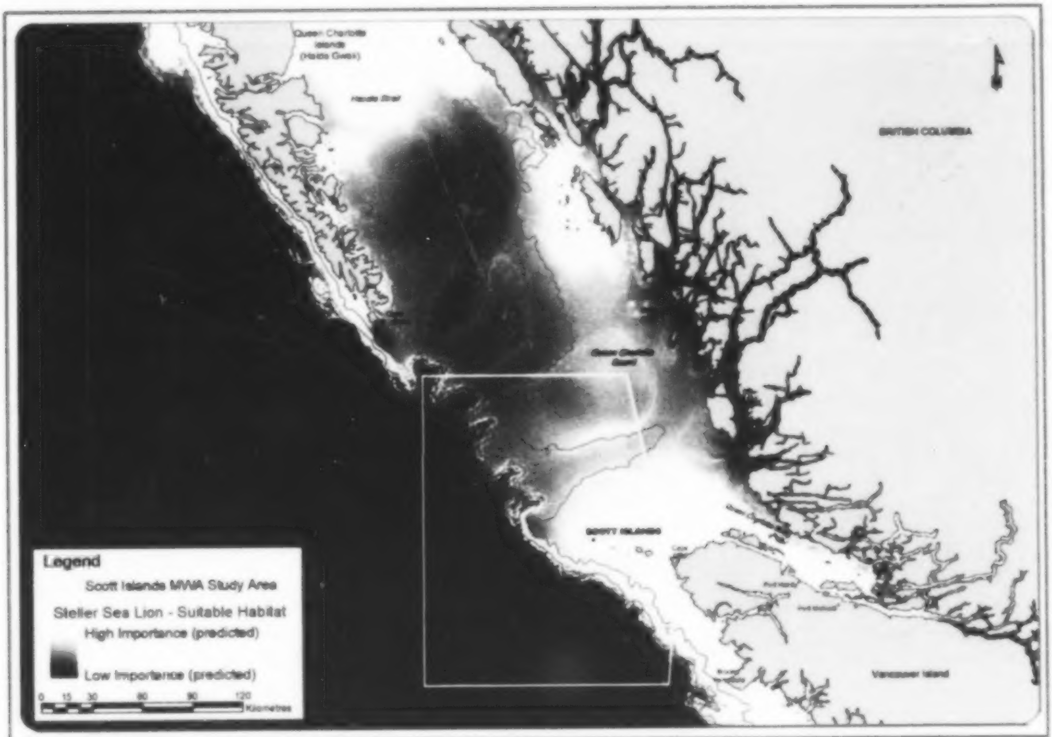

Queen Charlotte Islands (Haida Gwaii)
Hecate Strait
BRITISH COLUMBIA
Queen Charlotte Sound
SCOTT ISLANDS
Port Hardy
Vancouver Island
Legend
Scott Islands MWA Study Area
Steller Sea Lion - Suitable Habitat
High Importance (predicted)
Low Importance (predicted)
0 15 30 60 90 120
Kilometres

Figure 5-5 Probability predictions for Steller Sea Lion occurrences based on physical characteristics of the marine habitat. White regions represent areas of predicted higher probability of Sea Lion occurrence.

Data Source: S. Ban, E.J. Gregr, J. Porter, M. Foreman, A.W. Trites (Unpublished data)

Canada

6. Fish

6.1 Introduction

Over 200 species of marine fishes inhabit the central coast region of British Columbia, including many commercially important species (Haggarty *et al.* 2003). Much of the information in this section was obtained from Fisheries and Oceans Canada (DFO). As very little non-fisheries data exists for marine fish species, catch data is often used by fisheries managers to estimate distribution and population trends. Spatially explicit data was available for many species caught in the groundfish trawl and, to a lesser extent, for Pacific Halibut hook and line, ZN and C hook and line, and sablefish hook and line. For the salmon troll fisheries, data is summarized for each Pacific Fisheries Management Area (PFMA; Figure 6-1). For the salmon troll fishery, it is not possible at this time to restrict data queries to only that proportion of each PFMA contained within the MWA study area. Consequently, it is important to bear in mind that salmon troll catch and fishing effort statistics reported in this section over-represent the effort which actually occurs within the MWA study area. Also, for most commercially harvested species, fisheries data gives no information on population status, distribution, and movement of juveniles, as these individuals are generally too small to be caught in fishing nets (D. Welch, pers. comm.).

6.2 Rockfish

6.2.1 Distribution and Life History

Rockfish comprise a large group of demersal, long-lived, sedentary fishes of the genus *Sebastes*. These fish principally inhabit water of the continental shelf and upper slope regions, where they feed opportunistically on a variety of prey items including herring, sandlance, crabs, shrimp and euphausiids. Thirty-four species of rockfish, as well as two species of thornyheads (*Sebastolobus* spp.), inhabit the coastal waters of British Columbia. Although individual species distributions are not well-known, trawl fisheries catch data indicate that many of these species are present in commercially significant numbers within the Scott Islands MWA study area (Figures 6-2 to 6-4). Still other rockfish species are caught in the hook and line fishery, along with other demersal species such as skate and lingcod (Tables 6-1 to 6-3).

Table 6-1. Biological and Stock Information for rockfish species commercially harvested in British Columbia. Note, list is incomplete due to insufficient data for many rockfish species.

Common Name	Scientific Name	Habitat	Primary Fishery	Important Fishery?	Significant Bycatch in other Fisheries?	Stock Status
Yelloweye	*S. ruberrimus*	Inshore	H & L	Y	Y	Probable Decline
Quillback	*S. maliger*	Inshore	H & L	Y	Y	Probable Decline
Copper	*S. caurinus*	Inshore	H & L	Y	Y	Unknown
China	*S. nebulosus*	Inshore	H & L	Y	Y	Unknown
Black	*S. melanops*	Inshore	H & L	N	Y	Unknown
Tiger	*S. nigrocinctus*	Inshore	H & L	Y	Y	Unknown
Canary	*S. pinniger*	Shelf	Bottom Trawl	Y	N	Unknown
Silvergray	*S. brevispinis*	Shelf	Bottom Trawl	Y	N	Unknown
Yellowtail	*S. flavidus*	Shelf	Bottom and mid-water trawl	Y	Y	Apparent decline
Widow	*S. entomelas*	Shelf	Mid-water trawls	Y	Y	Unknown
Pacific Ocean Perch	*S. alutus*	Slope	Trawl	Y	Y (hake)	Declining
Yellowmouth	*S. reedi*	Slope	Bottom and mid-water trawl	Y	N	Average
Redstripe	*S. proriger*	Slope	Bottom and mid-water trawl	N	High Discard Rate	Decline until next recruitment event
Shortraker	*S. borealis*	Slope	Trawl and H & L	N	N	Low natural abundance
Rougheye	*S. aleutianus*	Slope	Trawl and H & L	Y	N	Uncertain
Bocaccio*	*S. paucispinus*	Slope	Trawl and H & L	N	Y	Strong Declines WCVI
Red-banded	*S. babcocki*	Slope	H & L	Y	N	Not assessed

* Listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), November 2002

Table 6-2. Monthly number of hooks fished in the ZN and C Hook and Line fisheries within the Scott Islands MWA study area, 1996-2003. Please note that the 3 or more vessel rule has been applied so catch and effort data by year and month has not been released for a small number of records.

Year	January	February	March	April	May	June	July	August	September	October	November	December
1996	0	0	0	0	668787	699988	391183	254548	0	0	0	0
1997	0	0	0	110427	383247	371762	104138	0	0	0	0	0
1998	0	0	0	264891	837493	409100	164700	0	0	0	0	0
1999	0	0	0	0	357318	680430	666244	213320	146800	0	0	0
2000	0	0	0	222037	1034860	1050672	0	0	0	0	0	33000
2001	0	0	0	656326	1383429	1424541	0	0	0	0	0	0
2002	0	18700	55000	0	0	792833	1022210	745434	90027	115275	0	0
2003	32230	51528	0	1069594	1370106	111464	0	0	20271	0	0	0

Table 6-3. Monthly catch in kilograms fished in the ZN and C Hook and Line fisheries within the Scott Islands MWA study area, 1996-2003. Please note that the 3 or more vessel rule has been applied so catch and effort data by year and month has not been released for a small number of records.

Year	January	February	March	April	May	June	July	August	September	October	November	December
1996	0	0	0	0	73969	65864	48638	44607	0	0	0	0
1997	0	0	0	7182	37396	32422	3395	0	0	0	0	0
1998	0	0	0	14857	59375	41541	17489	0	0	0	0	0
1999	0	0	0	0	34473	60379	63670	20751	14175	0	0	0
2000	0	0	0	55204	165756	125429	0	0	0	0	0	2659
2001	0	0	0	57361	154777	148689	0	0	0	0	0	0
2002	0	1522	4814	0	0	73293	96667	71166	13810	11911	0	0
2003	946	13177	0	104911	156041	32986	0	0	644	0	0	0

Rockfish species reach sexual maturity at age 7 to18, depending on the species, and individuals from some species may live in excess of 100 years. Most species mate in the mid- to late fall and release free-swimming larvae in the early spring. Once juveniles settle in an area, they rarely move in the course of their lifetime. Demographic research in British Columbia reveals episodic recruitment in rockfish, although the conditions responsible for this pattern are not known. Exceptional recruitment years occur at a frequency of every 15 or 20 years (Yamanaka and Lacko 2001). The physiology of the rockfish has important management implications, as rockfish swim bladders are prone to rupture when the fish is subjected to relatively minor pressure changes. As a result, rockfish bycatch mortality is extremely high after catch and release (Yamanaka and Lacko 2001).

6.2.2 Inshore Rockfish

Although all rockfish species are caught in existing hook and line and trawl fisheries in British Columbia, either as a targeted species or as bycatch, a subset referred to as the inshore rockfish have received special management attention. Inshore rockfish inhabit rocky reefs in relatively shallow water throughout BC. These species include yelloweye (*S. ruberrimus*), quillback (*S. maliger*), copper (*S. caurinus*), china (*S. nebulosus*), black (*S. melanops*) and tiger (*S. nigrocinctus*) rockfish. Of these, there has been sufficient data to directly assess the yelloweye and quillback rockfish populations, as there have been targeted fisheries for these two species (Yamanaka and Lacko 2001). Catch per unit effort summarized over large geographic areas is thought to be an inappropriate method for determining stock abundance for rockfish, as the mobility of the fishing fleet allows the catch rate to remain high despite potential serial depletion of individual reef stocks. Consequently, researchers have instead compared age distributions between heavily fished stocks and reference populations which have not been harvested. Stocks exposed to fisheries for a significant period of time were characterized by markedly truncated age distributions compared to reference sites, indicating older fish were being removed by the fishery faster than they could be replenished by immigration or population growth (Yamanaka and Lacko 2001).

Management recommendations stemming from the evidence for significant negative impacts of fisheries on rockfish populations have been formalized in the Rockfish/Lingcod Sustainability Strategy (RLSS; DFO Rockfish Website). Other concerns include incomplete data on total mortality from all commercial and recreational fisheries, inappropriately high rates of current fishing mortality, and current stock assessment methods, which are thought to be insufficient to monitor the effectiveness of management measures (Yamanaka and Lacko 2001). The RLSS calls for an account of all catch (landed and released), a decrease in fishing mortality, establishment of areas closed to all fishing, and an improvement of stock assessment and monitoring. In 2002, the Department implemented 28 interim Rockfish Conservation Areas (RCAs) in locations considered to be representative of rockfish habitat, and received proposals for more than 100 additional sites. As of April 2004, a total of 89 RCAs have been established. One RCA occurs within the Scott Islands MWA study area, and encompasses all the Scott Islands save Triangle Island. Topknot RCA is found just outside of the study area south of San Josef Bay, on the west coast of Vancouver Island (Figure 6-5). These areas will therefore be closed to hook and line fishing for rockfish in order to provide a network of habitats where rockfish can maintain high levels of productivity, allowing populations to recover (DFO Rockfish Website).

6.3 Other Groundfish

6.3.1 Flatfishes

There are four species of sole currently caught in the BC commercial trawl fishery: English (*Parophrus vetulus*), Rock (*Lepidopsetta petraborealis*), Dover (*Microsomus pacificus*), and Petrale (*Eopsetta jordani*) (Figure 6-6; DFO 1999a-d). Most species are relatively long-lived, utilize habitats in waters of varying depths, but typically migrate to deepwater to spawn. Of these, the conservation status of the Petrale sole is notable, as directed fisheries of this species are currently prohibited because of a longterm decline in its abundance (DFO 1999c).

Pacific Halibut (*Hippoglossus stenolepsis*) is another commercially important fish in the North Pacific. Males typically reach maturity at 8 years of age, while females are not sexually mature until age 12. Halibut are seasonal migrants, spawning during winter in deep water, but moving first to the edge of the continental shelf and then to shallower banks and coastal waters during summer. Individual halibut may migrate great distances to spawn. It is thought that the majority of BC halibut spawn hundreds of kilometres to the north in the Gulf of Alaska (Kramer *et al.* 1995). The International Pacific Halibut Commission (IPHC) is responsible for stock assessment, biological monitoring of the fishery, and research for the United States and Canada. Recommended allowable yields are submitted by the IPHC to the Canadian and U.S. governments. Each country is responsible for domestic allocation to various commercial, First

Nations, and recreational fisheries (DFO 2004a). IPHC statistics indicate that a significant halibut fishery exists within the Scott Islands MWA study area (Tables 6-4 and 6-5). Stock assessments of Pacific Halibut by the IPHC are coarse-grained, in that only one assessment is conducted for the entire coastal BC management region. A stock assessment of Pacific Halibut in 2003 revealed that current biomass and population estimates are well in excess of the historical minimum last observed in the 1970's. Although total number of individuals is estimated to be about 5-10 times higher than the historical benchmark, total biomass is only 2-3 times higher, due to a decrease in size at age for both males and females.

6.3.2 Pacific Cod

Pacific Cod (*Gadus macrocephalus*) are widely distributed in the coastal North Pacific, and they are commercially harvested along the west coast of Vancouver Island and in the Queen Charlotte Sound (Figure 6-7). These fish are relatively fast-growing, and reach sexual maturity at 2-3 years of age. They are opportunistic feeders, preying on invertebrates (amphipods, euphausiids, shrimp, and crabs) and fish (herring, sandlance, and flatfish). Depth distributions of fisheries landings indicate Pacific Cod migrates from shallow waters in spring and summer to deeper waters in fall and winter (DFO 1999e). This species is a major component of the groundfish trawl fishery, although annual yields have varied considerably over the last decade. Stock assessments for the West Vancouver Island and Hecate Strait stocks in 2001 and 1999, respectively, indicated low stock levels and resulted in marked reductions in fishing effort for this species. A 2003 research document, which incorporated additional shrimp trawl survey data, concluded that Pacific Cod stocks off western Vancouver Island had increased, and consequently suggested that higher catches could be taken (Starr *et al.* 2002).

6.3.3 Sablefish

Sablefish (*Anoplopoma fimbria*) inhabit shelf and slope waters, to a depth greater than 1500 m. Spawning occurs along the continental shelf, at depths greater than 1000 m. Larval sablefish migrate to inshore and shelf habitats, where they remain until the age of 2-5, at which point they migrate offshore. Although age, growth, and maturity parameters vary considerably across its range, growth is generally rapid, with females reaching sexual maturity in 3-5 years. Age distributions of this species are characterized by periodic years of high recruitment interspersed with low to moderate years (DFO 2003).

The sablefish fishery is one of the most economically important in Canada, with most fish exported to the Japanese market. Although sablefish are most commonly caught

Table 6-4. Pacific Halibut catch and fishing effort data in statistical areas overlapping the MWA study area and, for that subset of the total fishing effort data for which spatial data is supplied, within the MWA study area. The final column represents an estimate of total poundage within the MWA study area based on the ratio of columns 3 and 2, and the poundage for which there is spatial data presented in column 4. This estimate involves the assumption that the proportion of the total poundage in the MWA study area that has associated spatial data is similar to that proportion within the four IHPC statistical areas overlapping the MWA study area[1].

Year	Total poundage from tickets: IHPC Statistical Areas 90, 91, 100, 102	Poundage associated with Lat/Lon location: Statistical Areas 90, 91, 100, 102	Poundage from Lat/Lon logs, within the MWA study area	# of Trips with Lat/Lon in the MWA study area	Distinct vessels with Lat/Lon in the MWA study area	**Estimated Total Poundage within the MWA study area**
1996	2,787,763	1,065,962	542,263	98	50	1,418,156.30
1997	3,241,964	1,373,414	451,383	88	45	1,065,496.23
1998	3,793,510	1,647,825	590,100	121	57	1,358,487.86
1999	3,548,812	1,507,997	582,943	114	50	1,371,856.25
2000	2,939,609	1,289,558	478,973	69	34	1,091,841.81
2001	2,871,138	1,584,380	553,307	85	37	1,002,676.60
2002	3,763,496	2,367,433	1,028,211	143	48	1,634,541.71

[1] Kong, T. M. Unpublished data. Int. Pac. Halibut Comm. P.O. Box 95009, Seattle, WA 98145-2009. June 14, 2004.

Table 6-5. Total poundage of Pacific Halibut from tickets, by month, caught in IHPC Statistical Areas 90, 91, 100, 102. Missing months correspond to lack of data due to closures. The Pacific Halibut fishery in BC is typically open annually from mid-March to mid-November (IHPC Website)[1].

Year	March	April	May	June	July	August	September	October	November
1996	402,309	535,590	474,183	261,999	166,018	173,032	283,305	350,869	140,458
1997	231,137	691,496	661,970	335,297	233,103	105,536	380,152	398,313	204,960
1998	604,766	767,152	438,836	282,370	318,519	359,289	448,012	424,662	149,904
1999	336,891	1,075,812	482,740	305,258	287,762	211,470	366,266	364,632	117,981
2000	281,819	666,509	243,033	153,893	169,938	202,050	536,114	435,537	250,716
2001	432,121	493,859	276,495	324,588	187,680	186,729	392,080	358,230	219,356
2002	375,154	830,072	514,644	346,568	261,882	356,891	520,016	447,231	111,038
Total	2,664,197	5,060,490	3,091,901	2,009,973	1,624,902	1,594,997	2,925,945	2,779,474	1,194,413

[1] Kong, T. M. Unpublished data. Int. Pac. Halibut Comm. P.O. Box 95009, Seattle, WA 98145-2009. June 14, 2004.

throughout BC in the trap fishery, this species is harvested within the MWA study area using only hook and line (Tables 6-6 and 6-7) and trawl methods (Figure 6-7). A 2003 stock assessment revealed significant declines in all BC stocks from the early 1990's to mid -1990's, followed by a period of comparative stability at lower abundances up until 2002, when northern stocks increased somewhat. Stocks are anticipated to improve over the next few years, as stronger 2000 and 2001 year classes enter the population. However, the population will continue to be assessed annually, in the absence of a more sophisticated population dynamics model (DFO 2003a, Kronlund *et al.* 2003).

6.3.4 Pacific Hake

The offshore stock of Pacific Hake (*Merluccius productus*) is found in BC waters from the US border to Queen Charlotte Sound. Offshore Hake is mainly pelagic, utilizing ocean floor and mid-water habitats, and feeds predominantly on krill along the shelf break during the summer months. In winter, they migrate offshore and to the south to California. Sexually mature at around 3 years of age, Pacific hake live approximately 20 years. Summer distribution of this species has been well-studied, and the population centre is known to shift latitudinally across years. Throughout the 1970's and 1980's, the northern extent of the distribution reached Queen Charlotte Sound, while there was a marked northward shift in the distribution during the 1990's, and hake were found feeding along the shelf break as far as 59 degrees North in the Gulf of Alaska.

Pacific Hake populations were relatively stable at 2 to 3 million tonnes from 1972-1982. However, after reaching a population peak of 6 million tonnes in 1987, Pacific Hake stocks in the North Pacific have been steadily declining, reaching a low of 0.7 million tonnes in 2001. Although this species has a fairly wide distribution, which includes the Scott Islands MWA study area, fisheries are limited to southwest Vancouver Island, as an enzyme associated with a parasite of the Pacific Hake causes the flesh to break down shortly after death. Consequently, the Canadian mid-water trawl fishery for this species must occur in close proximity to established processing plants in Ucluelet and Port Alberni (DFO 2003b).

6.3.5 Lingcod

The lingcod (*Ophiodon elongatus*) is unique to the west coast of North America, and is found off the coast of BC at depths of 30-400m. They prefer rocky habitats, but juveniles may also be found in less typical flat-bottomed environments. Lingcod are a sedentary species,

Table 6-6. Monthly number of hooks set in the sablefish fishery within the Scott Islands MWA study area, 1996-2003. Note that there are no records of sablefish caught by trap within the Scott Islands MWA study area.

Year	January	February	March	April	May	June	July	August	September	October	November	December
1996	60500	7500	24550	88350	90200	96350	1400	5600	15900	68250	82500	0
1997	18600	12900	31600	30500	94800	271750	66900	56400	73500	194700	169400	29750
1998	0	15600	84150	224000	172950	181315	93015	126200	285000	90400	80850	0
1999	0	0	30750	267685	303625	190150	189200	119925	112450	52400	10600	0
2000	0	21000	103100	169695	217200	110750	42000	117100	26250	57340	63700	25300
2001	13200	105050	153600	481856	673000	271900	93200	0	51530	14600	46600	6000
2002	3350	0	36900	539302	457643	143950	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0

Table 6-7. Monthly catch in kilograms in the sablefish fishery within the Scott islands MWA study area, 1996-2003. Note that there are no records of sablefish caught by trap within the Scott Islands MWA study area.

Year	January	February	March	April	May	June	July	August	September	October	November	December
1996	22167	5211	9605	39190	84469	45179	1898	4844	20477	93431	74124	
1997	3370	11089	19908	17969	38917	119131	39146	22443	55187	93006	55953	10700
1998		6967	35398	55003	166346	139168	65152	69143	104178	33889	91181	
1999			14552	106598	171666	80185	67717	54263	54223	41173	2399	
2000		4728	4550	43235	59871	41415	14424	55330	27364	38439	28538	3387
2001	3189	43780	83333	149756	183123	130083	40944		27704	13172	13774	1323
2002	1143		6416	102118	147900	120216	52971	13290	15667	9848		
2003		998	2378	1983	2018	10363	23621	13962	24053		12994	10461

which live up to a maximum of 20 years and reach lengths of 90-120 cm, with females generally living longer and reaching larger sizes than males. Spawning takes place from December to March, and males guard the egg masses until they hatch in mid-March to April. Adult lingcod are highly predatory, and feed predominantly on other fish such as herring or Pacific Hake. Offshore stocks off the west coast of Vancouver Island and in Queen Charlotte Sound are predominantly caught in the trawl fishery (Figure 6-7), although there are some hook and line (Tables 6-2 and 6-3, in part) and recreational fisheries. Stocks in these regions are thought to be stable, and total allowable catch recommendations have not changed significantly in recent years. However, a conservative approach to harvest rates has been recommended, as no strong year classes have been observed, and this species has been overexploited in inshore areas such as the Strait of Georgia (DFO 2002a).

6.4 Salmon

6.4.1 Juvenile Migration

On the west coast of North America, the continental shelf represents a major migration highway and rearing area for juvenile salmon (Hartt and Dell 1986; Welch *et al.* 2002). Juvenile salmon generally exhibit a northward migration from their natal river system along the continental shelf up to the Aleutians. Only at this time, some six months after ocean entry, do juveniles leave the continental shelf for the open waters of the North Pacific Ocean and Bering Sea. Thus, for many stocks originating from rivers south of the MWA study area, this region forms part of an important juvenile migratory corridor for all five species of North American salmon (Figure 6-8; Welch *et al.* 2002).

6.4.2 Juvenile Stock Composition

Traditionally, the migration of juvenile salmon has been studied using externally attached tags and coded-wire tags (CWT). More recently, DFO researchers have also started using genetic analyses to determine juvenile stock composition along the west coast of Vancouver Island and Queen Charlotte Islands. Both genetic and CWT data from these areas indicate that a diversity of stocks migrate along the outer coast of Vancouver Island during the summer. Stock composition varies seasonally. In summer, chinook catches are dominated by Upper Columbia River and Snake River stocks, while coho catches are dominated by the Columbia River and coastal stocks from the United States and southern BC. In fall and winter, most juvenile chinook originated from west coast Vancouver Island stocks. Coho stocks from the east and west coast Vancouver Island dominate in fall. Although these stocks are still abundant in the winter, migratory juveniles from coastal BC become numerically dominant at this time (Trudel *et al.* 2004). Similarly, summer samples of sockeye salmon are composed of Fraser River stocks, while fall stocks in Queen Charlotte Sound consist almost entirely of local Rivers Inlet and Smith Inlet stocks (Welch *et al.* 2004). Juvenile sockeye are generally absent from the region during the winter months (M. Trudel, pers. comm.).

These patterns support the notion of a general northward migration of juvenile salmon, in which certain stocks move rapidly through specific regions while others remain as local residents for more prolonged periods. The resident Rivers Inlet and Smith Inlet (Owikeno) sockeye stocks have declined precipitously since 1994, a population collapse which has been attributed to poor marine survival (DFO 2003d). Given that migratory Fraser River stocks have not experienced similar declines, the temporal patterns in the stock composition data suggest that these stocks experienced poor marine survival by remaining in the south-central coastal region of BC, an area characterized by poor marine conditions in recent years (Welch *et al.* 2004).

6.4.3 Adult Salmon

In contrast to juvenile migratory patterns, adult salmon of most species are exclusively distributed seaward of the shelf break, only returning to the shelf immediately prior to sexual maturation (Welch *et al.* 2002; Figure 6-9 and 6-10). Most adults return to the shelf from June to November, though some stocks of Chinook initiate their upriver migration as early as March (Healey 1991). However, it is important to note that some stocks of coho and chinook salmon spend their entire life on the continental shelf (M. Trudel, pers. Comm.)

Although little is known about the offshore distribution of adult salmon in the region, significant numbers of returning coho, chinook and sockeye salmon populations likely pass through the MWA study area. Coho salmon originating from natal rivers along the west coast of Vancouver Island, the Fraser River, and various Washington and Oregon stocks exhibit general southward migration patterns along the continental shelf, and CWT tagged individuals have been recovered in the region (Weitkamp and Neely 2002).

Migration behaviour of returning Fraser River sockeye stocks around the northern end of Vancouver Island is correlated reliably with open-ocean sea-surface temperatures (SST; McKinnell *et al.* 1999). When SSTs are anomalously warm a larger proportion of the returning

Fraser River Sockeye return to their natal river via the Johnstone Strait. However, in years characterized by cooler SSTs, the majority have tended to return to the Fraser River by passing to the west of Vancouver Island and travelling through Juan de Fuca Strait. This route would entail that the bulk of the population would pass through the MWA study area.

6.4.4 Salmon Fisheries

Salmon species in British Columbia are commercially harvested using troll, seine, and gillnet methods. The two latter methods are restricted to inshore areas (some of which are adjacent to the study area), while salmon troll is also permitted in offshore areas within the MWA study area (Tables 6-8 and 6-9; DFO 2003c).

Table 6-8. Total annual catch in pounds for six Fisheries Statistical Areas partially contained within the Scott Islands MWA study area, 1996-2003.

Area	1996	1997	1998	1999	2000	2001	2002	2003	Total
108	8008	27216	7826	14381	5827	9236	10094	0	82588
109	0	0	0	5912	3149	12630	0	0	21691
110	0	0	3096	12855	0	3025	0	0	18976
111	1799	0	7215	3673	4154	1737	0	0	18578
127	136267	154231	162619	26073	58145	15637	215352	117419	885743
130	0	0	14981	1630	0	0	0	0	16611

6.5 Forage Fish

A number of species of smaller fish also occur within the study area, many of which are important prey items for the bird, mammal, and fish populations that use the region. Despite the ecological importance of many of these species, critical population and distribution information is incomplete, as insufficient research effort has been allocated to non-commercial fish species.

Table 6-9. Average monthly catch in pounds 1996-2003 for six Fisheries Statistical Areas partially contained within the Scott Islands MWA study area.

Area	January	February	March	April	May	June	July	August	September	October	November	December
108	0	0	0	0	1011	1717	1883	2606	2554	0	504	0
109	0	0	0	0	188	1172	1155	197	0	0	0	0
110	0	0	387	219	0	159	1607	0	0	0	0	0
111	0	0	0	140	556	536	531	225	335	0	0	0
127	0	0	427	8317	30246	20241	14438	14780	18246	7034	1026	162
130	0	0	0	0	0	204	1004	868	0	0	0	0

6.5.1 Pacific Sandlance

Often referred to as 'the quintessential forage fish', this fish is probably the single most important species along the BC coast, as it is a staple in the diet of many species of birds, mammals, and fish. Sandlance are found in nearshore areas characterized by fine gravel or sandy substrates, most commonly in waters less than 50m deep (Macy *et al.* 1978). Sandlance behaviour is characterized by daily crepuscular migrations from benthic substrates (where they bury themselves overnight) to pelagic waters, where they school and feed. Seasonally, sandlance are most abundant in the water column from spring to late summer. In winter, these fish appear to remain buried in the substrate.

Sandlance schools can consist of hundreds to thousands of individuals. These schools are fairly dense when moving, but become more diffuse during feeding periods, where individual fish spread both vertically and radially through the water column. Adult sandlance feed on various varieties of macro-copepods, chaetognaths, and fish larvae. Adults deposit lipids rapidly from February through to early summer, at which time lipid reserves start to decline (Robards *et al.* 1999a). Growth of other species in this genus occurs mostly in the first two years (Macer 1966), although growth and lipid deposition rates are both food and density dependent. In the Gulf of Alaska, spawning occurred in late September or early October on fine gravel and sandy beaches (Robards *et al.* 1999a). Larvae hatch just prior to the spring phytoplankton bloom. Sandlance recruit immediately to the next-year spawning adults (Kimura *et al.* 1992).

Adult mortality rates are strongly influenced by the intensity of seabird and fish predation (Bailey *et al.* 1991). As a prey item, sandlance are most energetically valuable in early summer (Willson *et al.* 1999). In addition to its high lipid content relative to other fish, the elongated shape of the sandlance make it easy for young chicks to swallow, and allows adult alcids such as Rhinoceros Auklet and Tufted Puffin to carry dozens of individual sandlance in a single bill-load (Ainley *et al.* 1996). Studies indicate that chicks reared on sandlance gained weight more rapidly than on other fish (Wilson *et al.* 1999), and that, in areas where sandlance are a primary prey, chick feeding rates, chick weights, and fledging success are higher when sandlance are abundant (Uttley *et al.* 1994). Bird species in the region for which the sandlance is an important diet component include Sooty Shearwater, Pelagic Cormorant, Pigeon Guillemot, Tufted Puffin, Rhinoceros Auklet, and Marbled Murrelet (Wilson *et al.* 1999). Many fish species including

Pacific Cod, Lingcod, Pacific Dogfish (*Squalus acanthias*), Sole, Pacific Halibut, and various salmon species also rely heavily on sandlance. Although this species is harvested intensely in the western Pacific and North Atlantic, there is currently no sandlance fishery in British Columbia.

6.5.2 Pacific Saury

Pacific Saury (Cololabis saira) is a widely distributed forage fish in the North Pacific found from Japan east to the Gulf of Alaska, and south to Mexico. The Pacific Saury is a highly migratory species elsewhere within its range (Tian *et al.* 2002), but the migratory behaviour of the northeast Pacific population is not well known. A relatively short-lived species (maximum reported age is 2 years), it may reach 40 cm in length. Adult fish are usually found offshore, foraging near the surface in schools, where they are preyed upon by marine mammals, other fishes, and seabirds (Eschmeyer *et al.* 1983). In some years, Pacific Saury represents an important diet item for Rhinoceros Auklets breeding at Triangle Island (Bertram *et al.* 2002). Although a commercial fishery exists in Japan for this species, the Pacific Saury is not currently harvested in the northeast Pacific.

6.5.3 Kelp Greenling

The kelp greenling is a relatively small non-migratory fish of rocky nearshore habitats, found most often in and around kelp beds. Occasionally found to depths of 150m, these fish are more commonly found at depths of 45 m or less, including intertidal areas. Kelp greenlings spawn in fall and early winter. Egg masses are often guarded by males throughout the winter until their hatch in early spring. Adult fish eat a wide variety of benthic prey, including snails, octopi, and algae. Kelp greenling are a component of chick diet for a number of breeding seabird species at Triangle Island (Bertram *et al.* 2002). While they are not an important diet item for Rhinoceros Auklets, kelp greenling may be more important to Pigeon Guillemots breeding in the region (M. Hipfner, pers. comm.). There is no commercial fishery for this species in British Columbia.

6.5.4 Juvenile Rockfish

Juvenile Rockfish are an important prey item for at least two Triangle Island breeding seabirds: the Tufted Puffin and the Common Murre (M. Hipfner, pers. comm.). Once planktonic larvae metamorphose into juveniles, they leave the upper mixed zone and move closer to shore during the spring months (Larson *et al.* 1994), and finally move to deeper habitats characteristic of adult rockfish (Love *et al.* 1998).

6.5.5 Pacific Herring

Pacific Herring are small (~ 30 cm) pelagic fish which travel and feed on the continental shelf, usually in very large schools which may consist of millions of individuals. Adult herring on the west coast of Vancouver Island migrate to shallow inshore waters in the late fall and leave, after spawning, in late March and April (DFO 2002c).

6.5.6 Surf Smelt

Surf smelt are a schooling forage fish that frequent shallow nearshore areas. Found from Southern California to Alaska, these fish typically spawn on high intertidal beaches of sand and gravel. Surf Smelt are primarily a recreational fishery in BC, although some commercial fishing does also take place. Surf Smelt are found all along the BC coast but, due to the recreational nature of the fishery, fisheries are restricted to large population centres. Population declines are suspected, but this species is difficult to manage, as catch statistics are currently unavailable.

Surf Smelt is not a component of the seabird chick diet at Triangle Island, but is a diet item elsewhere in BC. It is, for example, a major diet item at Seabird Rocks on the west coast of Vancouver Island (Bertram *et al.* 2002) and is known to have a similar energy density to sandlance (Anthony *et al.* 2000). This species is also known to be an important diet item for seals and salmon species.

6.5.7 Pacific Sardine

A schooling pelagic species, Pacific Sardines (*Sardinops sagax*) spawn in coastal regions off southern California and Baja California, but migrate to British Columbia. Sardines reach a maximum age of 9 years and a maximum length of 31 cm. Approximately 10% of population occurs in BC waters during the summer, but migratory patterns are complex and depend on oceanographic conditions. After an increase in sea surface temperature through the North

Pacific in the early 1990's, sardine stocks increased dramatically. A more recent shift towards cooler ocean temperatures is hypothesized to signal an ensuing decline in sardine productivity. The potential harvest in the Canadian trawl fishery for this species, which extends as far north as northwest Vancouver Island, is based on the U.S. estimate of total abundance (DFO 2002b).

6.6 Invertebrates

6.6.1 Shrimp and Prawn

There are 7 shrimp species, all from the family Pandalidae, that are commercially fished in British Columbia. These include prawns, the largest of the pandalid shrimp. All shrimp species of this family undergo a change of sex in mid-life, transforming from males to females, although some individuals, known as primary females, bypass the male phase. Spawning occurs in late autumn or winter, and females carry the developing eggs on their appendages until hatch in the spring. Shrimp utilize a variety of habitats, from rocky bottoms to mud and sand, depending on the species. Most remain near the ocean bottom, but some species will move into the water column periodically. Shrimp species are relatively sedentary but certain species, such as pink shrimp, change their distribution pattern substantially over the course of the year (DFO 1999f).

Shrimp and prawns are harvested using both bottom trawl and longline trap techniques. The most productive trawl fisheries are concentrated off western Vancouver Island, including areas within the Scott Islands MWA study area. Longline trap fisheries for prawns are restricted to inshore areas, where this species is most abundant, although opportunity remains to expand the fishery to offshore waters (DFO 1999g). Stock assessments are complicated by the multiplicity of shrimp species, but there is growing concern that the current size of the commercial fleet is too large, and that sufficient stocks may not exist to support this level of fishing effort.

6.6.2 Other invertebrates

There are fisheries for other marine invertebrates in the region, including crab, green and red sea urchin, geoduck, and sea cucumber. However, these are restricted to coastal areas that lie outside of the Scott Islands MWA study area.

6.7 Species at Risk

6.7.1 Bocaccio Rockfish.

This species was listed as Threatened by COSEWIC in November 2002, and addition to the SARA legal list is expected, pending a public consultation process. Globally, the

International Union for the Conservation of Nature (IUCN) considers the species to be Critically Endangered, based on assessments of the central and northeast Pacific populations.

Although considered to be of low commercial importance, the Bocaccio Rockfish is harvested throughout British Columbia, where it is caught predominantly along the edge of the continental shelf (Figure 6-4). The largest catches are taken from the northwest coast of Vancouver Island and Queen Charlotte Sound. The trawl fishery is responsible for the majority of the annual harvest (200-300 t/year, with an additional discard catch of 9 t), but the species is also harvested in the hook and line fishery (2 t/y). In addition, the species is reported as a 'nuisance bycatch' species in the salmon troll fishery, although the impact of the salmon troll fishery is thought to be relatively minor. Off the west coast of Vancouver Island (where abundance estimates are thought to be most reliable), numbers appear to have declined by approximately 95% in the last two decades, and by 90% in the last 10 years. COSEWIC identified commercial and recreation harvest, and bycatch from fisheries as the principal threats to Bocaccio Rockfish (COSEWIC 2002).

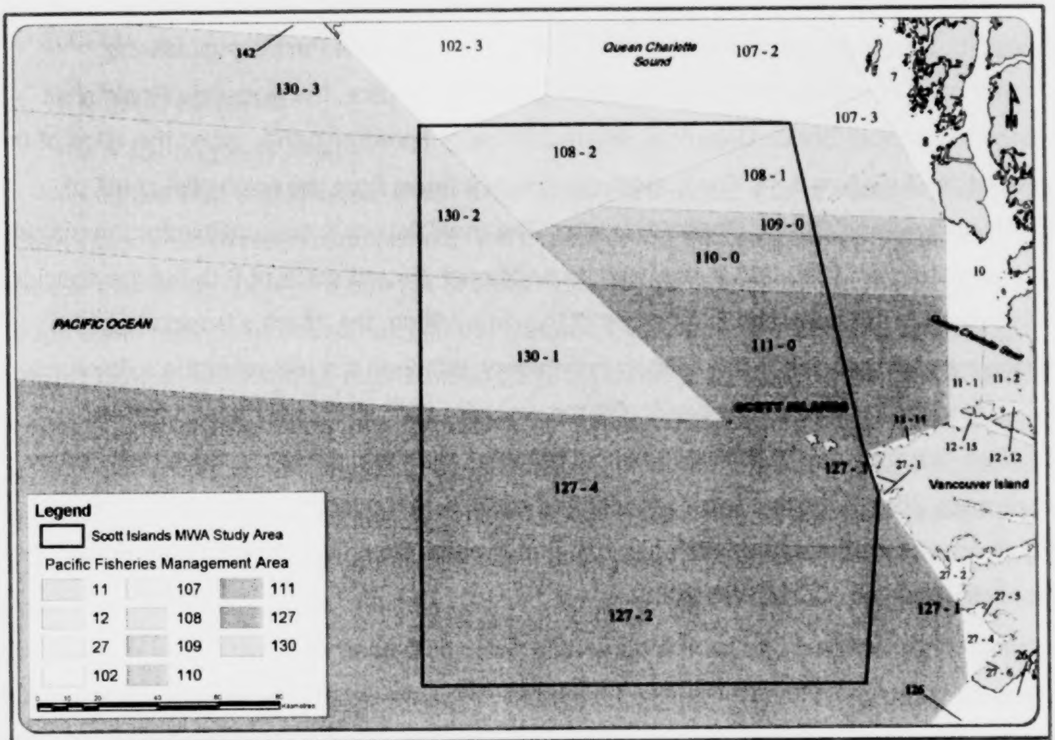


Figure 6-1 Pacific Fisheries Management Areas in the vicinity of the Scott Islands MWA study area.

Data Source: Fisheries and Oceans Canada

Canada

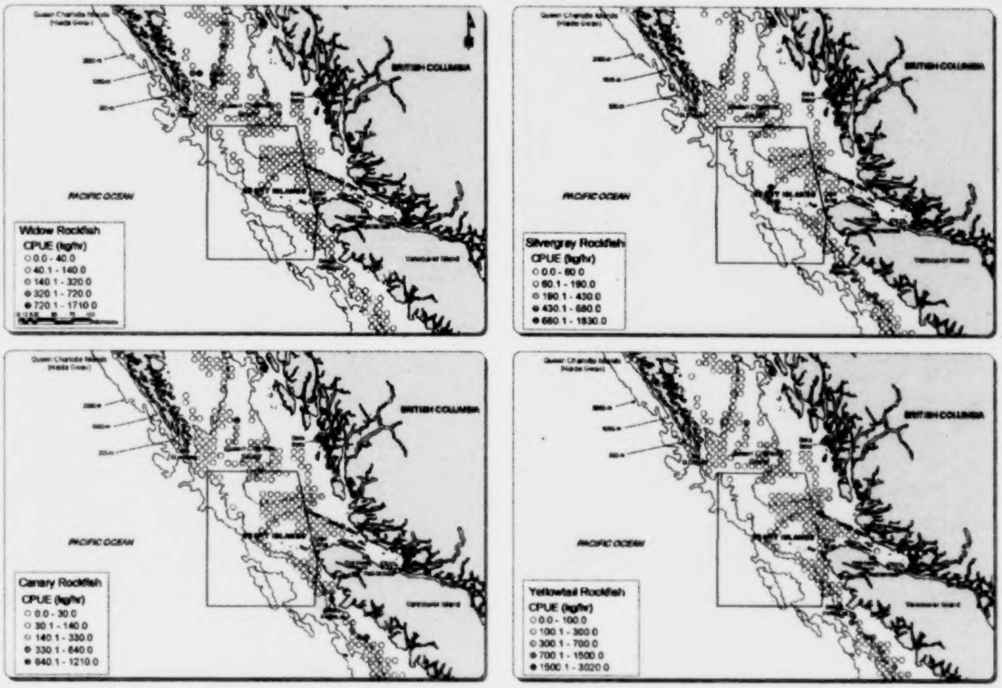


Figure 6-2 Groundfish trawl catch locations and catch effort for four shelf rockfish (*Sebastes spp.*) in the vicinity of the Scott Islands MWA study area. Data represent an 8-year annual average (1996-2003)

Data Source: Fisheries and Oceans Canada

Canada

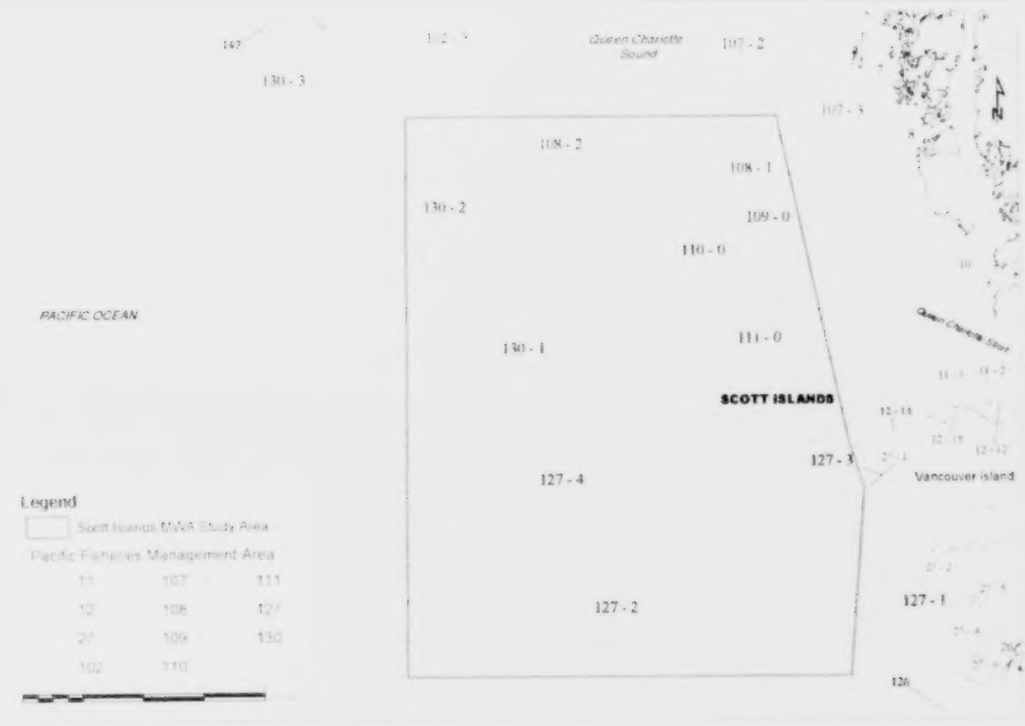


Figure 6.1 Pacific Fisheries Management Areas in the vicinity of the Scott Islands MWA study area.

Data Source: Fisheries and Oceans Canada

Canada

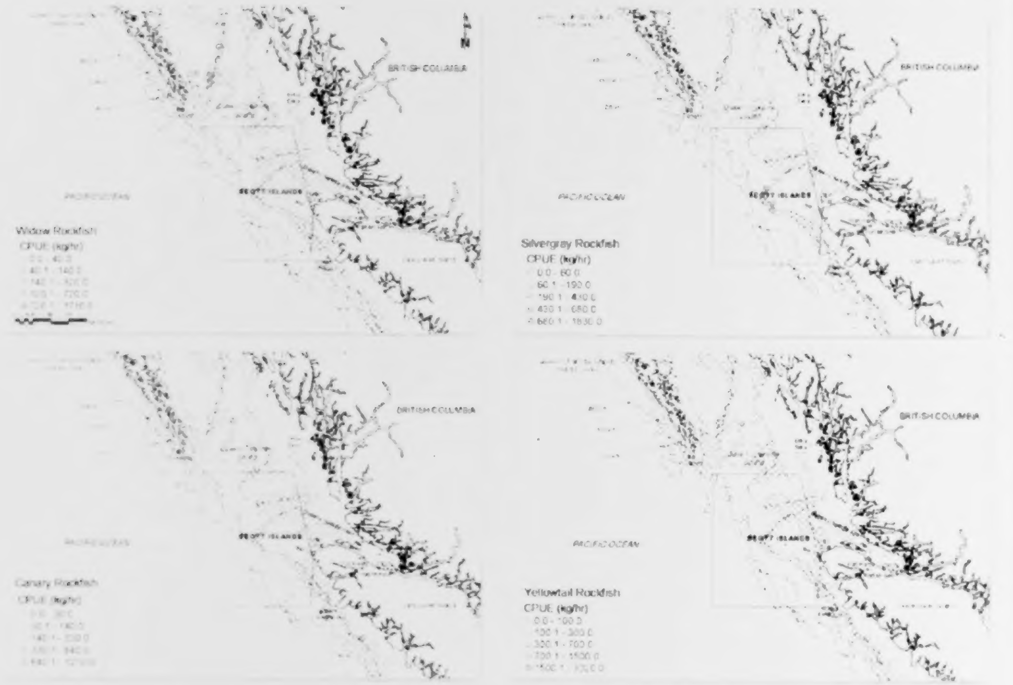


Figure 6-2 Groundfish trawl catch locations and catch effort for four shelf rockfish (*Sebastes spp.*) in the vicinity of the Scott Islands MWA study area. Data represent an 8-year annual average (1996-2003).

Data Source: Fisheries and Oceans Canada

Canada

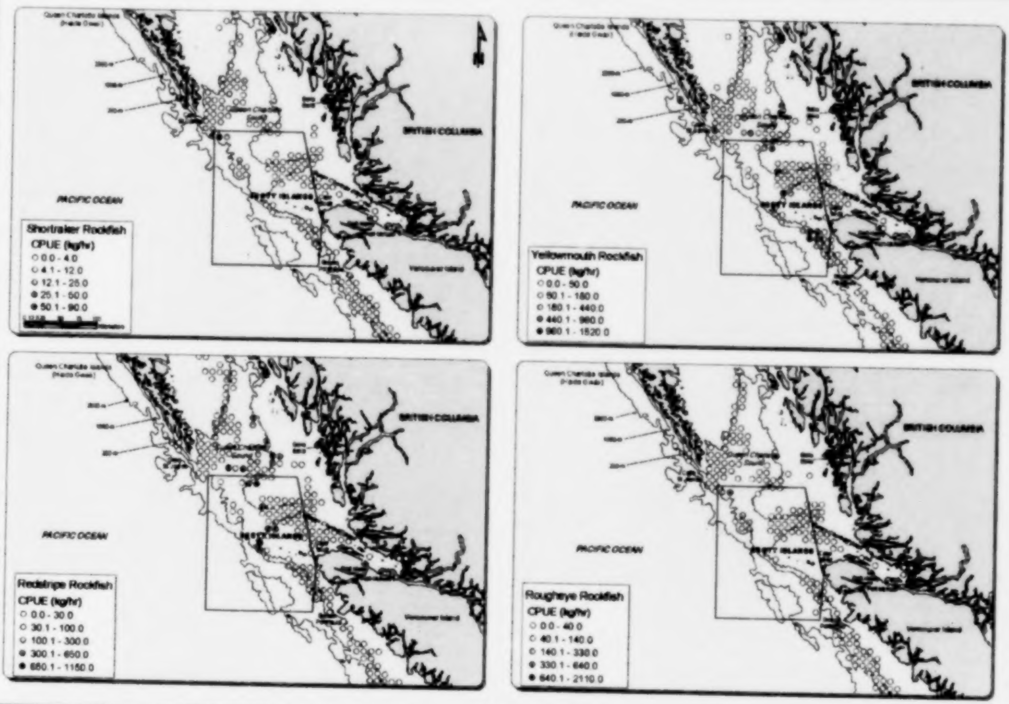


Figure 6-3 Groundfish trawl catch locations and catch effort for four slope rockfish (*Sebastes spp.*) in the vicinity of the Scott Islands MWA study area. Data represent an 8-year annual average (1996-2003).

Data Source: Fisheries and Oceans Canada

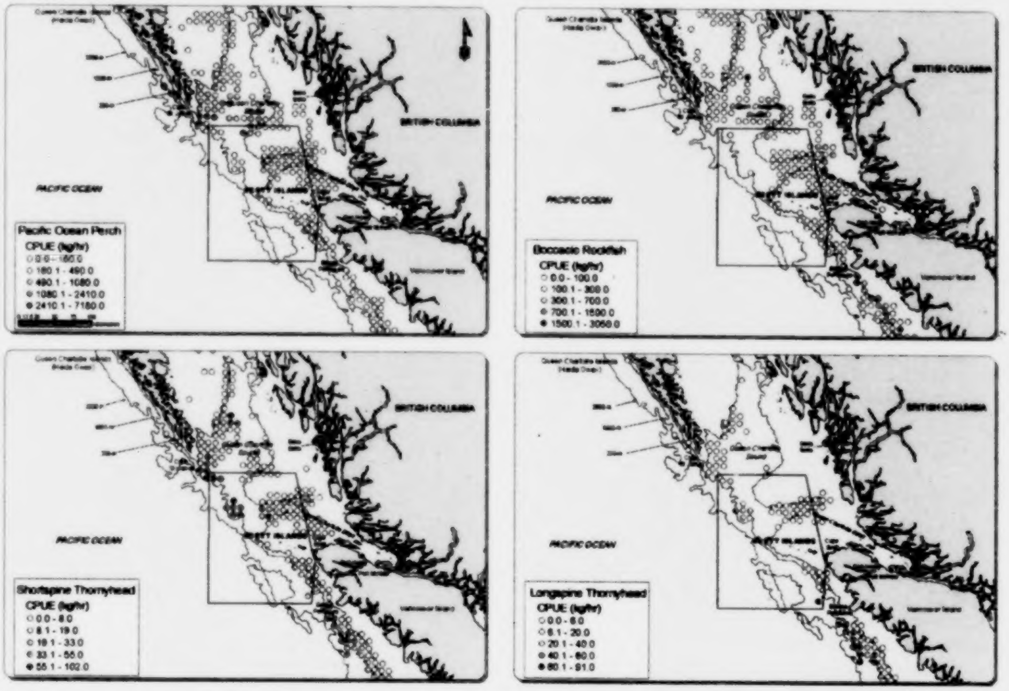


Figure 6-4 Groundfish trawl catch locations and catch effort for slope rockfish (*Sebastes spp.*) in the vicinity of the Scott Islands MWA study area (continued). Data represent an 8-year annual average (1996 - 2003)

Data Source: Fisheries and Oceans Canada

Canada

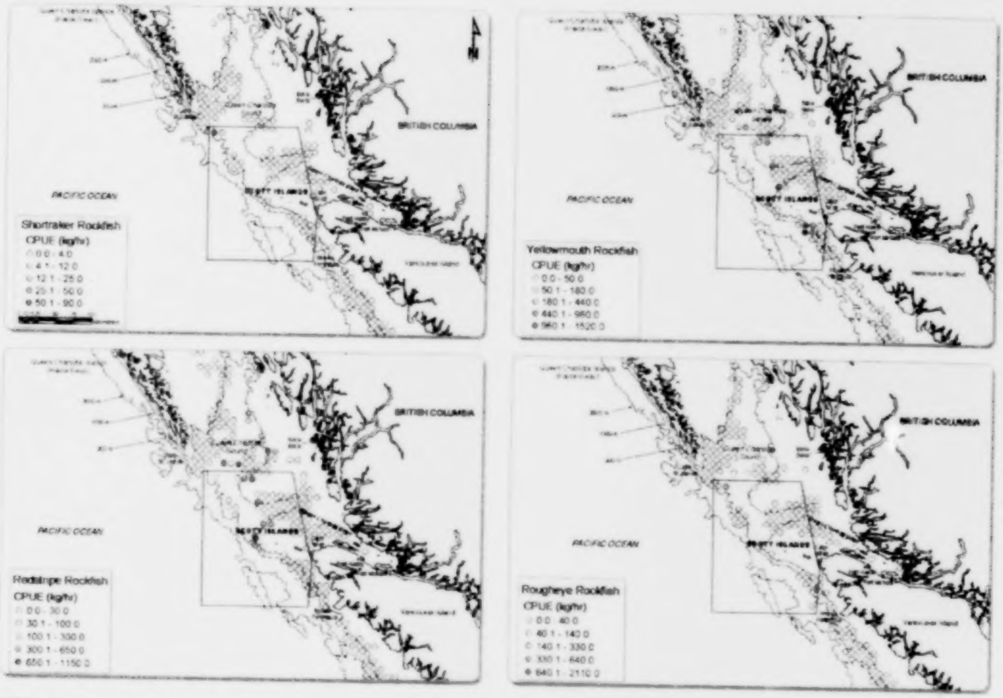


Figure 6-3 Groundfish trawl catch locations and catch effort for four slope rockfish (*Sebastes* spp.) in the vicinity of the Scott Islands MWA study area. Data represent an 8-year annual average (1996-2003).

Data Source: Fisheries and Oceans Canada

Canada

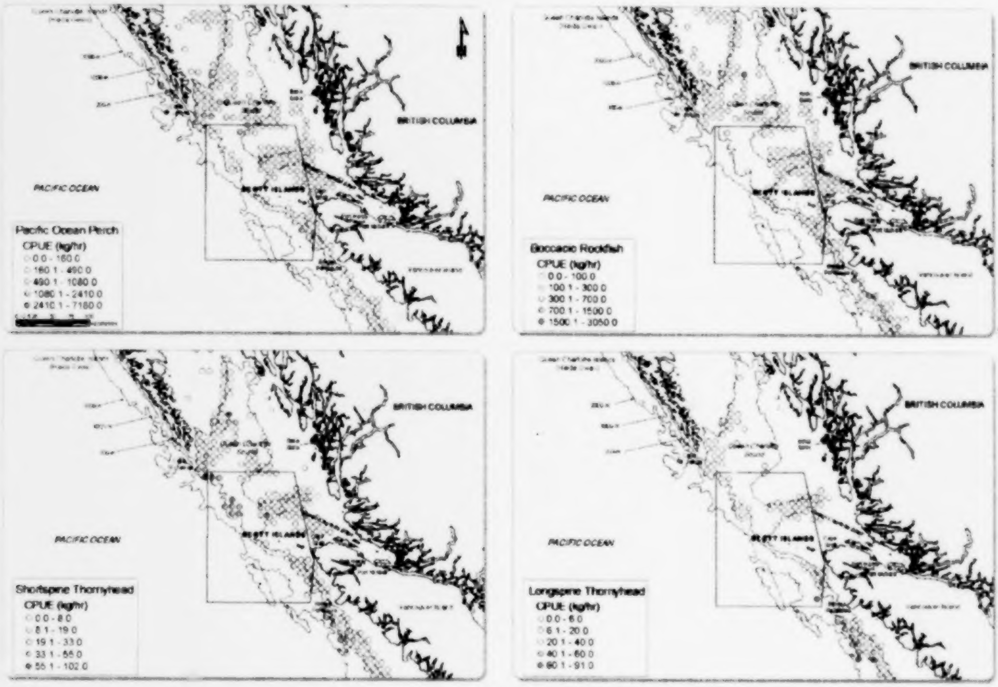


Figure 6-4 Groundfish trawl catch locations and catch effort for slope rockfish (*Sebastes spp.*) in the vicinity of the Scott Islands MWA study area (continued). Data represent an 8-year annual average (1996 - 2003)

Data Source: Fisheries and Oceans Canada

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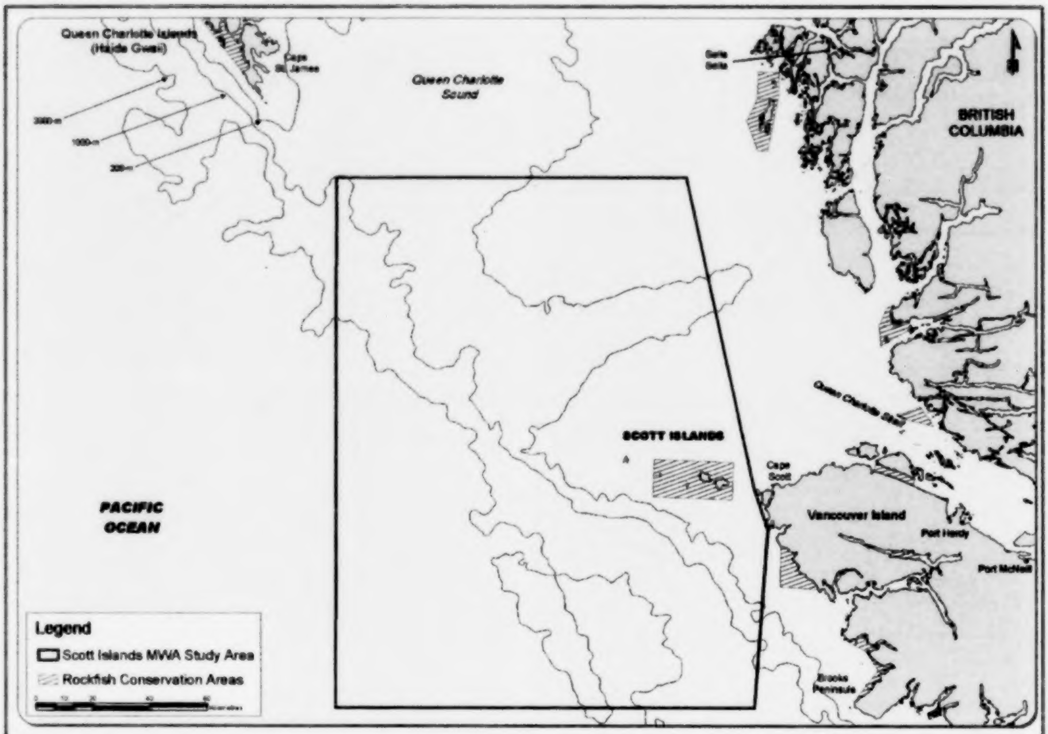

Figure 6-5 Rockfish Conservation Areas in the vicinity of the Scott Islands MWA study area.

Data Source: Fisheries and Oceans Canada

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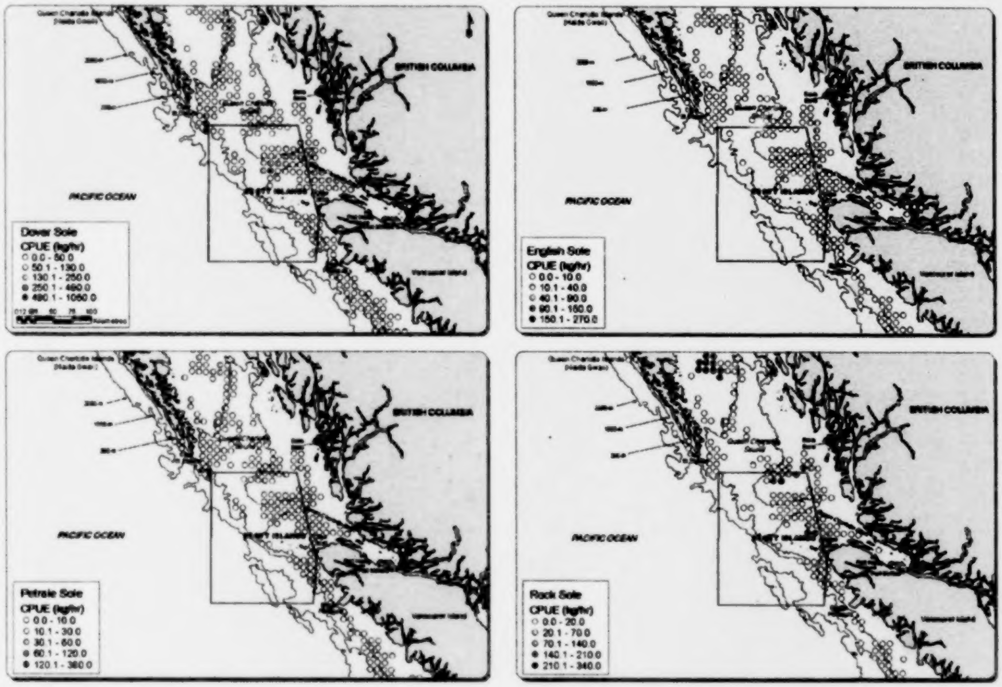

Figure 6-6 Groundfish trawl catch locations and catch effort for four Dover soles (*Microstomus pacificus*), English Sole (*Parophrys vetulus*), Petrale Sole (*Eopsetta jordani*) and Rock Sole (*Lepidopsetta petraborealis*) in the vicinity of the Scott Islands MWA study area. Data represent an 8-year annual average (1996-2003).

Data Source: Fisheries and Oceans Canada

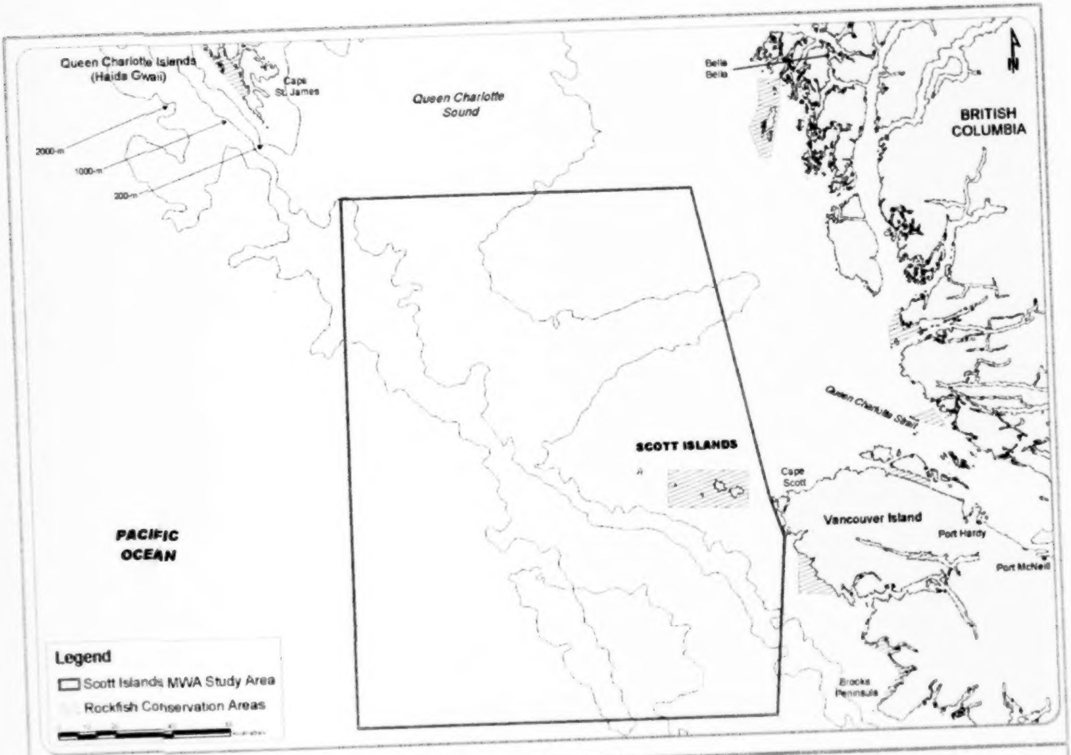

Figure 6-5 Rockfish Conservation Areas in the vicinity of the Scott Islands MWA study area

Data Source Fisheries and Oceans Canada

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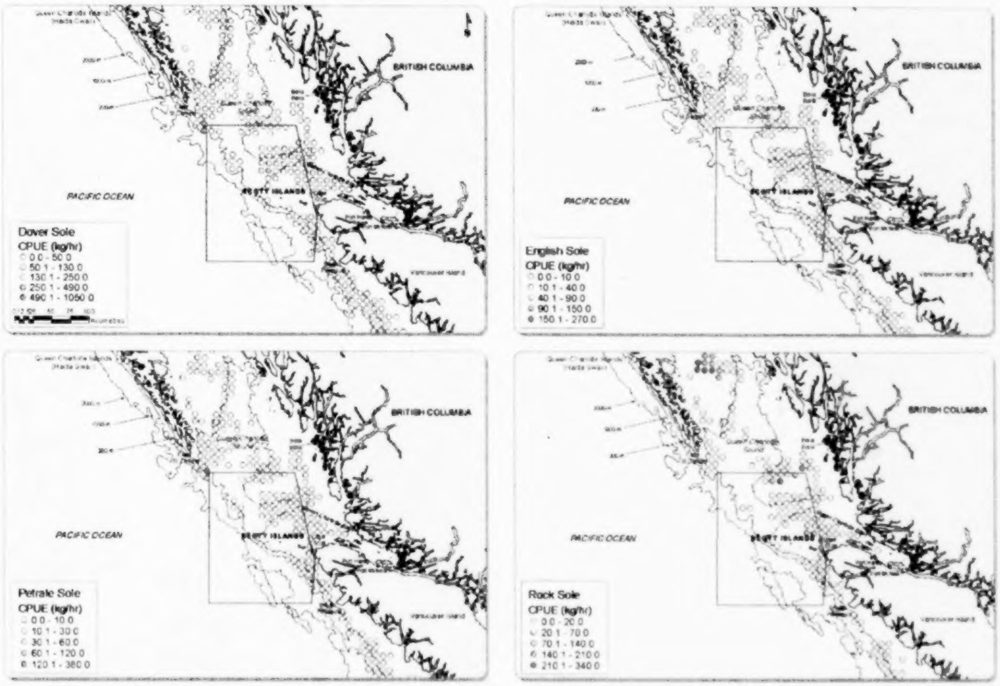

Figure 6-6 Groundfish trawl catch locations and catch effort for four Dover soles (*Microsomus pacificus*), English Sole (*Parophrus vetulus*), Petrale Sole (*Eopsetta jordani*) and Rock Sole (*Lepidopsetta petraborealis*) in the vicinity of the Scott Islands MWA study area. Data represent an 8-year annual average (1996-2003).

Data Source: Fisheries and Oceans Canada

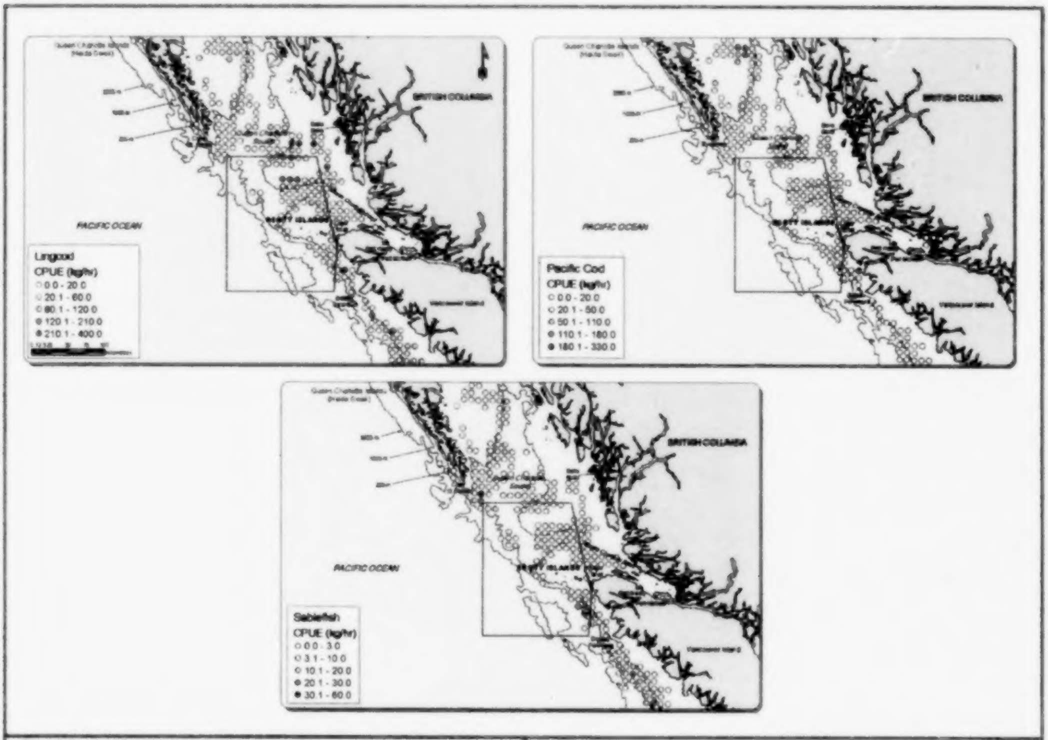

Figure 6-7 Groundfish trawl catch locations and catch effort for Lingcod (*Ophiodon elongatus*), Pacific Cod (*Gadus macrocephalus*), and Sablefish (*Anoplopoma fimbria*) in the vicinity of the Scott Islands MWA study area. Data represent an 8-year annual average (1996-2003)

Data Source: Fisheries and Oceans Canada

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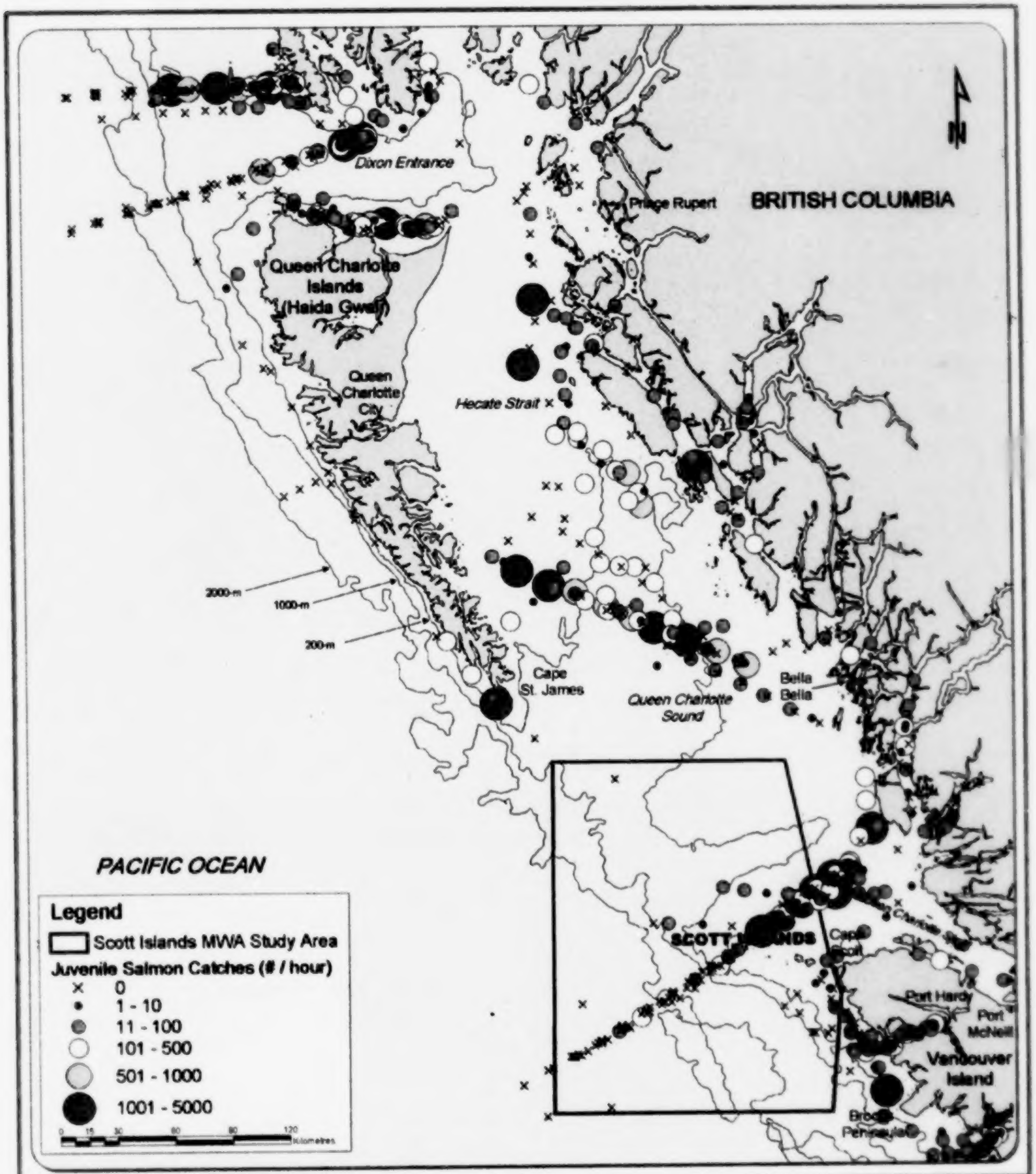

Figure 6-8 Distribution of juvenile salmon catches off North and Central British Columbia in the vicinity of the Scott Islands MWA study area. Zero catches are indicated by a 'x', and positive catches by a circle scaled relative to the total number of juvenile salmon caught per hour. All data area combined; this includes all species (pink, chum, sockeye and coho) and all data from February to November, 1995 - 2004.

Data Source: Fisheries and Oceans Canada

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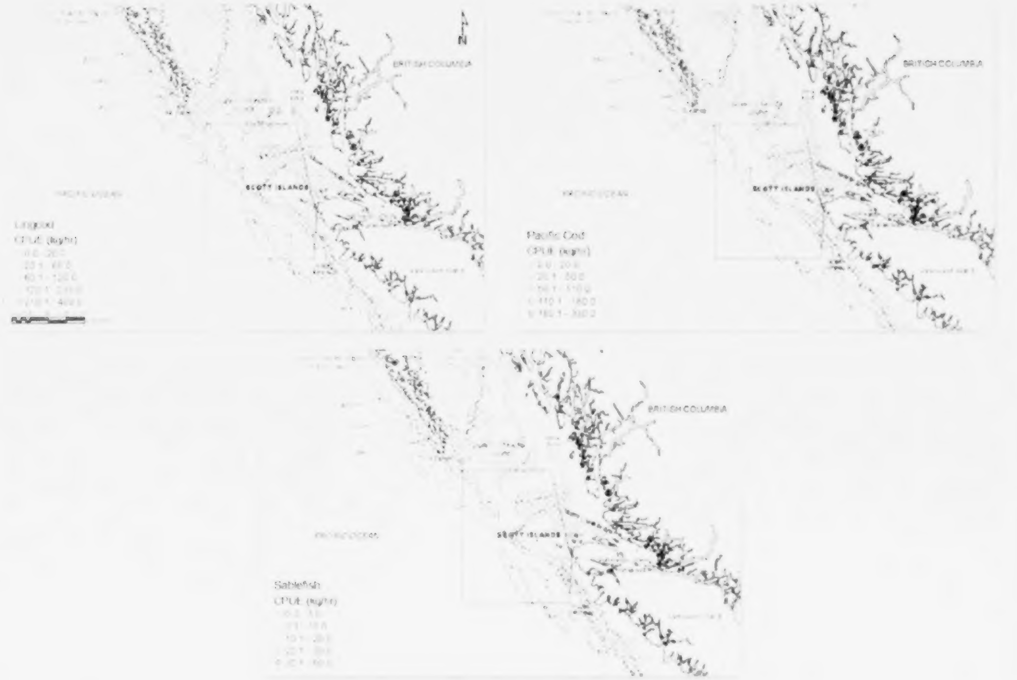
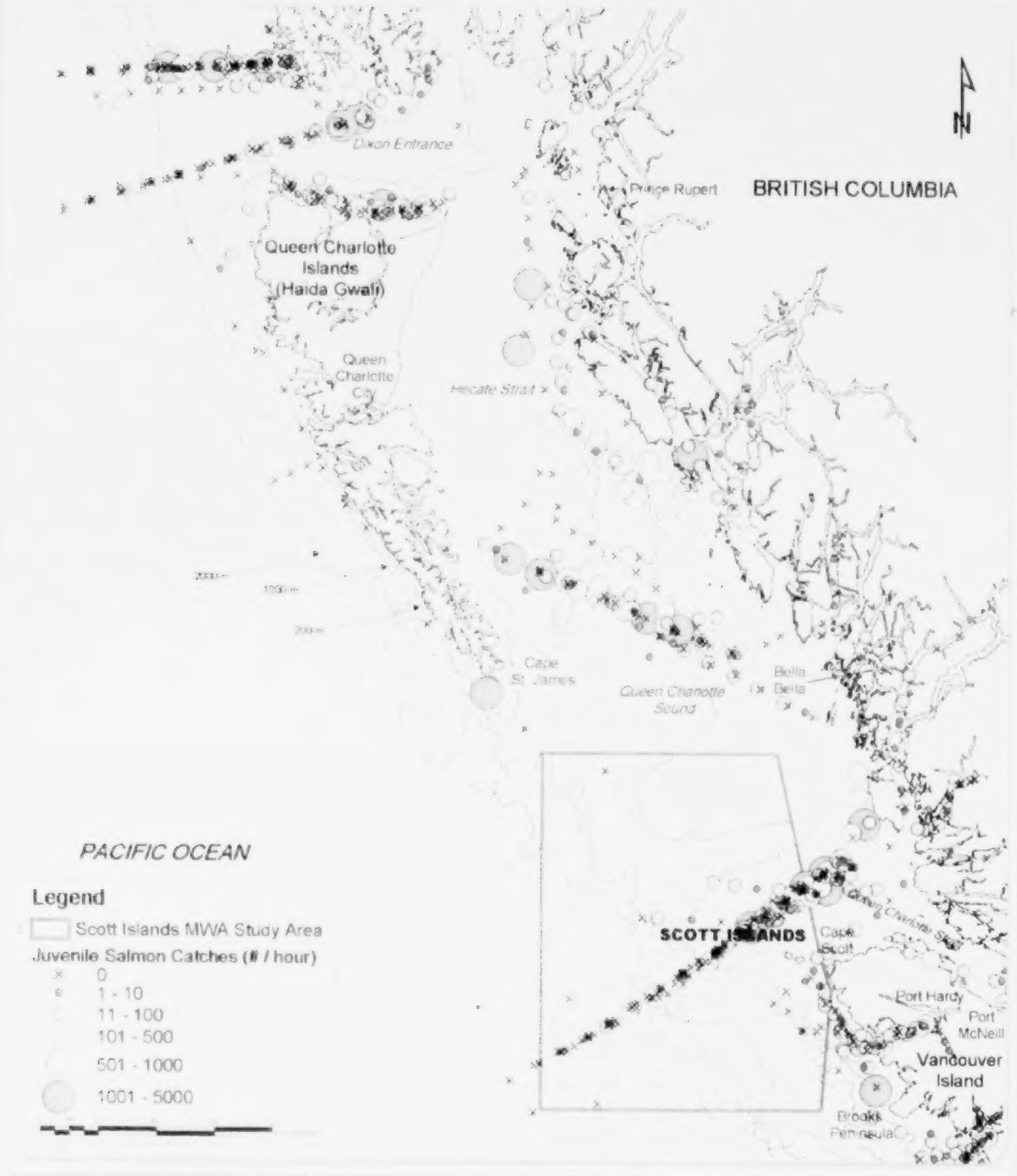


Figure 6-7 Groundfish trawl catch locations and catch effort for Lingcod (*Ophiodon elongatus*), Pacific Cod (*Gadus macrocephalus*), and Sablefish (*Anoplopoma fimbria*) in the vicinity of the Scott Islands MWA study area. Data represent an 8-year annual average (1996-2003).

Data Source: Fisheries and Oceans Canada



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Data Source: Fisheries and Oceans Canada

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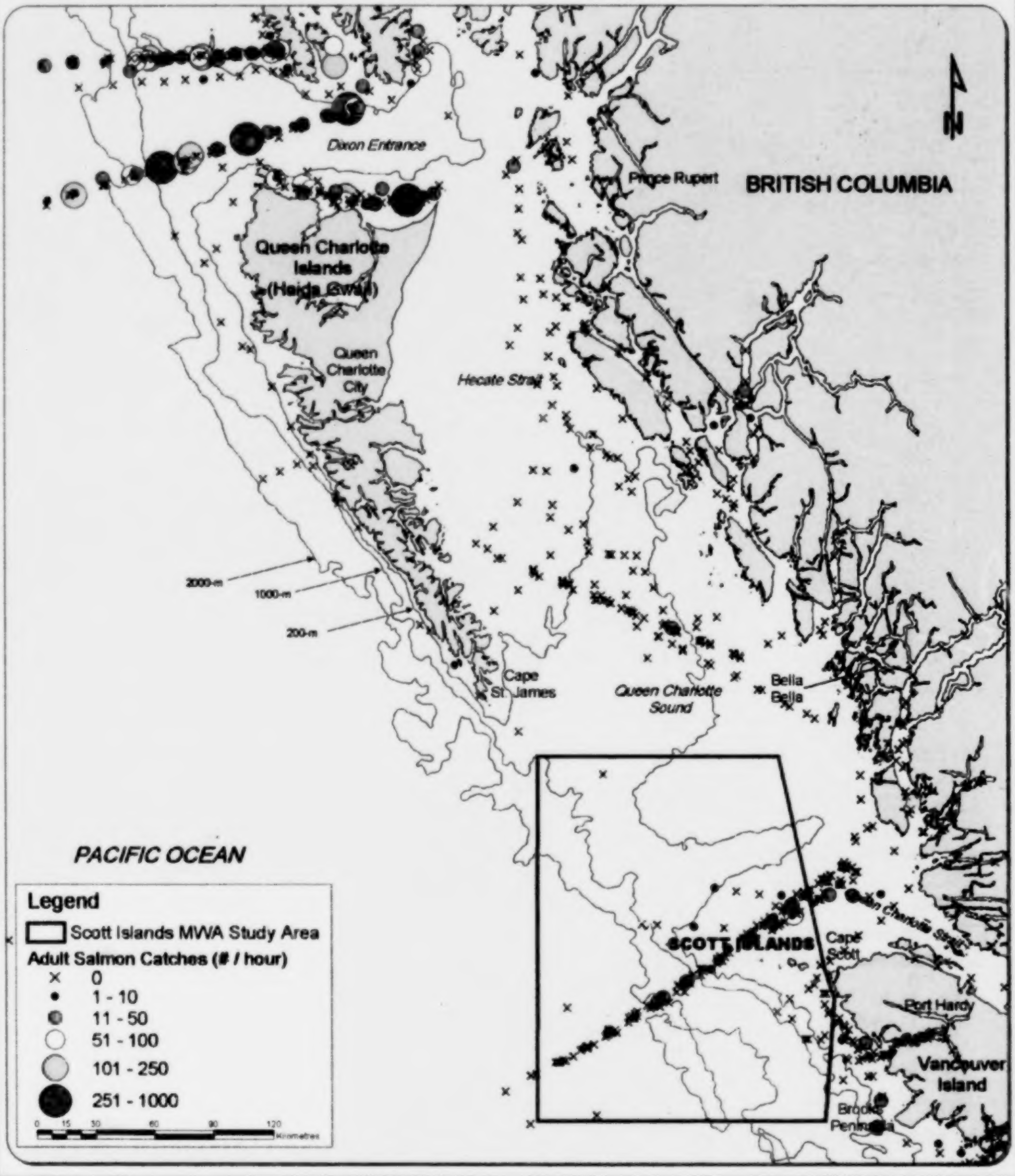

Figure 6-9 Distribution of adult salmon catches off of North and Central British Columbia in the vicinity of the Scott Islands MWA study area. Zero catches are indicated by a 'x', and postive catches by a circle scaled relative to the total number of adult salmon caught per hour. All data area combined; this includes all species (pink, chum, sockeye and coho) and all data from February to November, 1995 - 2004.

Data Source: Fisheries and Oceans Canada

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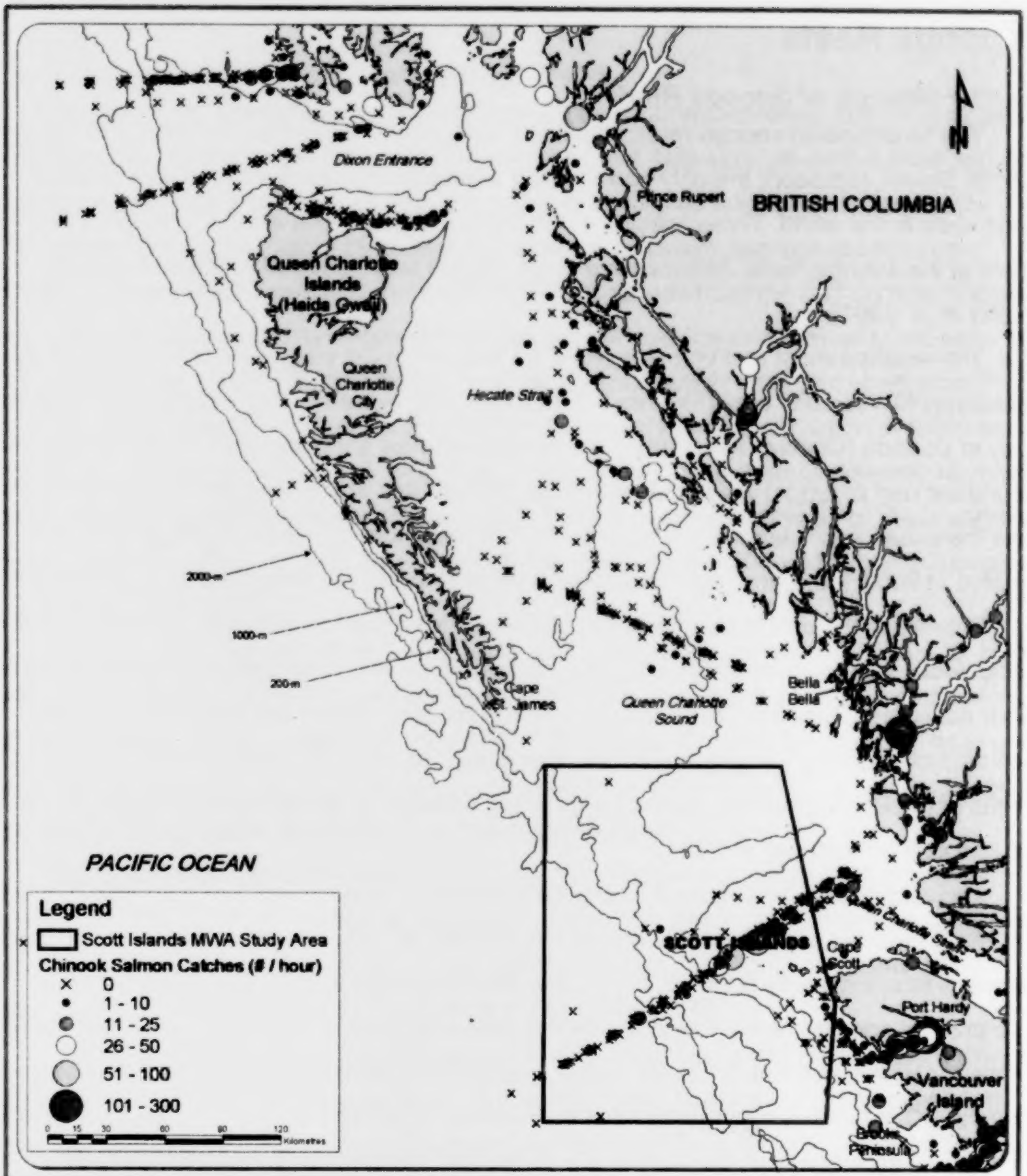

Figure 6-10 Distribution of Chinook salmon catches off North and Central British Columbia in the vicinity of the Scott Islands MWA study area. Zero catches are indicated by a 'x', and positive catches by a circle scaled relative to the total number of adult salmon caught per hour. Due to complex life histories of Chinook, it is not possible at present to determine the absolute age of Chinook based on size of catch. All data from February to November, 1995 - 2004 are also combined.

Data Source: Fisheries and Oceans Canada

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Produced by CWS GIS Unit
Date: 14 April 2004

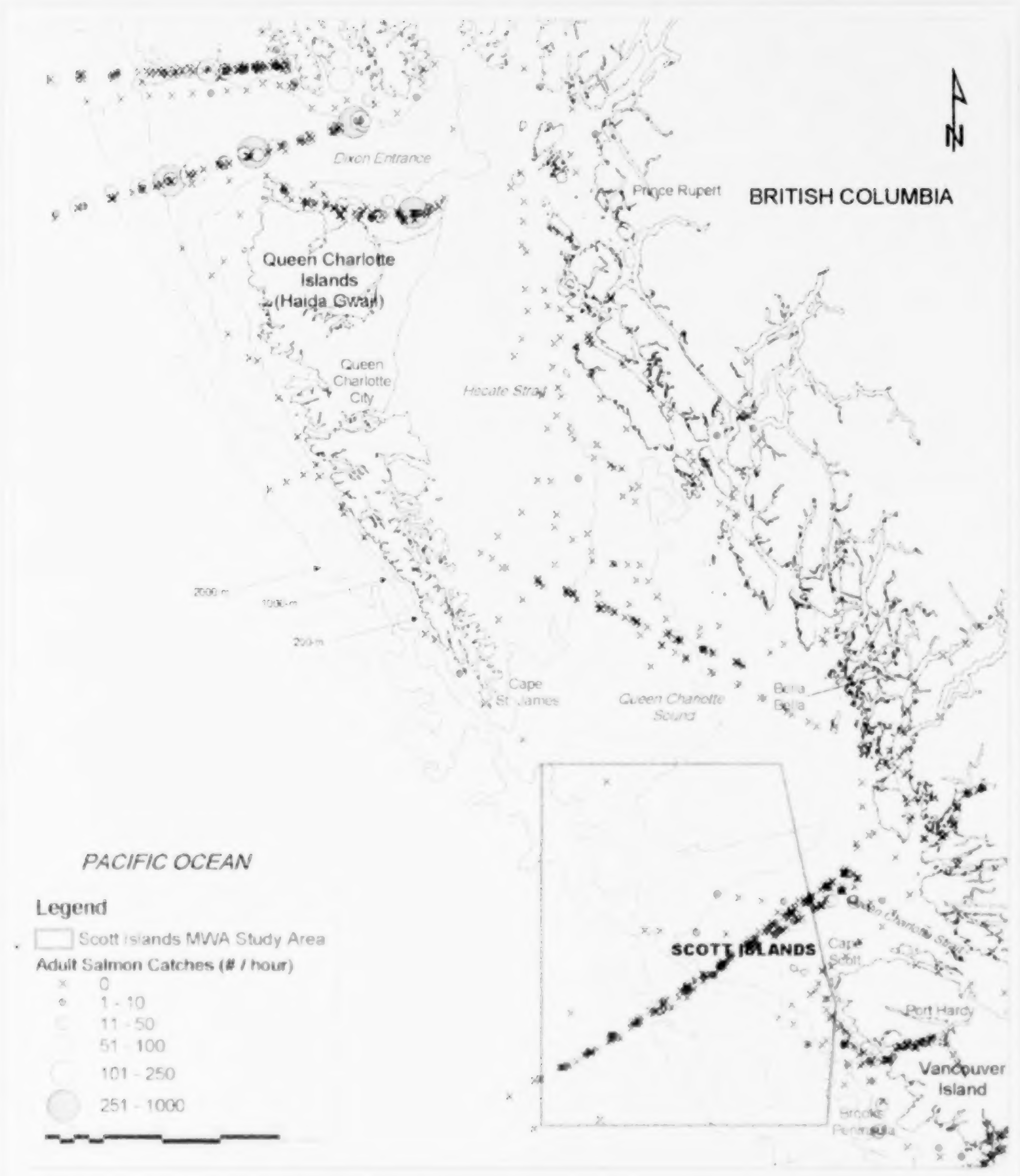

Figure 6.9 Distribution of adult salmon catches off of North and Central British Columbia in the vicinity of the Scott Islands MWA study area. Zero catches are indicated by a 'x' and postive catches by a circle scaled relative to the total number of adult salmon caught per hour. All data area combined, this includes all species (pink, chum, sockeye and coho) and all data from February to November, 1995 - 2004.

Data Source: Fisheries and Oceans Canada

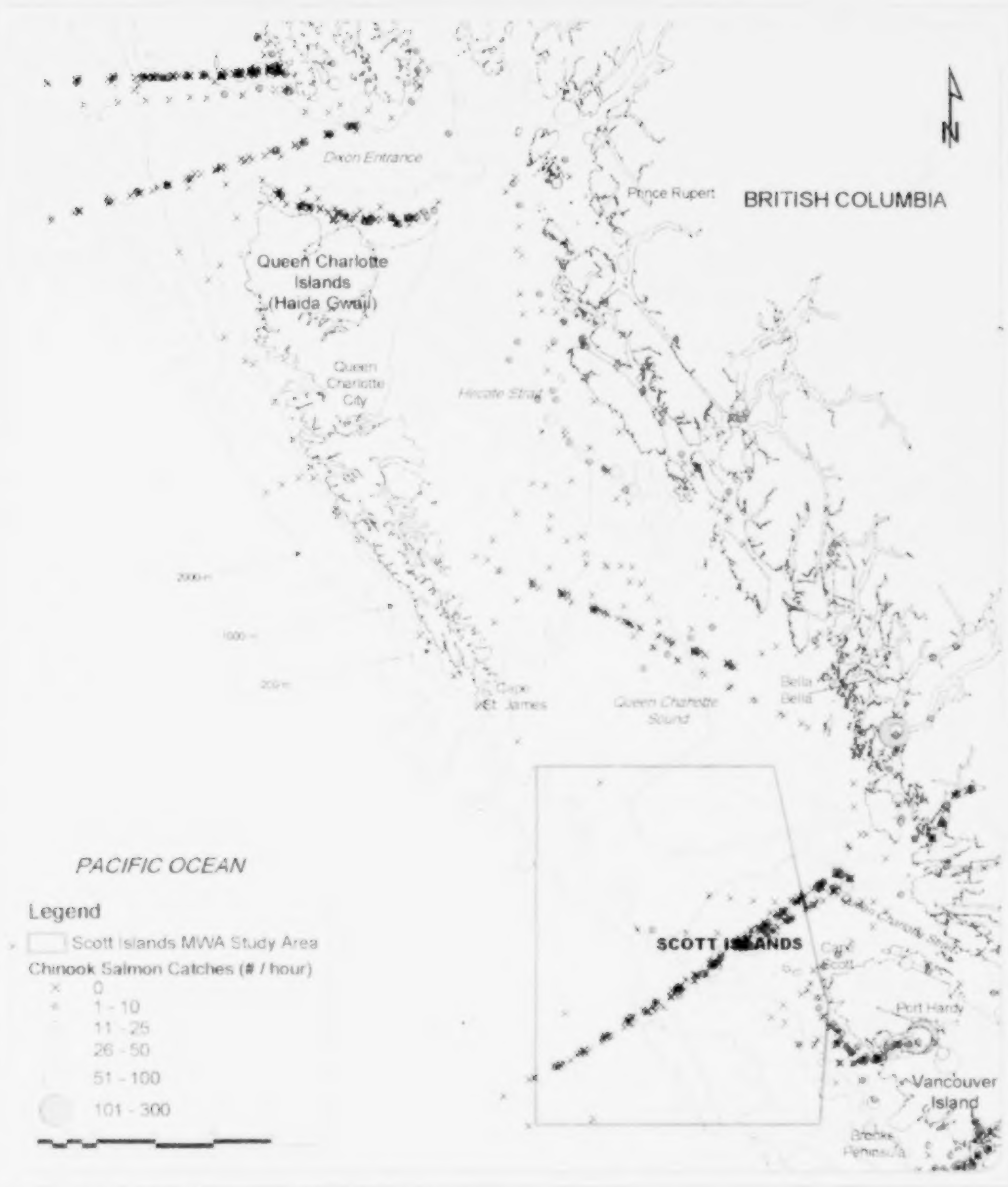

Figure 6-10 Distribution of Chinook salmon catches off North and Central British Columbia in the vicinity of the Scott Islands MWA study area. Zero catches are indicated by a 'x' and positive catches by a circle scaled relative to the total number of adult salmon caught per hour. Due to complex life histories of Chinook, it is not possible at present to determine the absolute age of Chinook based on size of catch. All data from February to November 1998 - 2004 are also combined.

Data Source: Fisheries and Oceans Canada

7. Sponge Reefs

7.1 Biology of Sponge Reefs

The hexactinellid sponge reefs, found in five locations within Hecate Strait and Queen Charlotte Sound, represent the only documented examples of siliceous framework skeleton sponge reefs in the world. Three species of the order Hexactinosida are the principle frame-builders of the sponge reefs: *Heterochone calyx*, *Farrea occa*, and *Aphrocallistes vastus*. (Krautter *et al.* 2001).

The southernmost reef complex (Reef D) falls within the suggested boundaries of the Scott Islands MWA study area (Figures 7-1 and 7-2). Discovered in 1987-88 by the Geological Survey of Canada (Conway *et al.* 1991), the reef complexes are composed of sponge bioherms (steep-sided reef mounds) which may reach heights of 19 m and extend for several kilometres across the ocean floor (Jamieson and Chew 2002). Maximum age of the sponge reefs is estimated at 9000 years and reef development has been ongoing since that time (Conway *et al.* 1991). Conditions thought to be critical for the formation of hexactinellid sponge reefs include specific geological conditions of a relict, glaciated seafloor with low sedimentation rates where coarser substrates, produced regionally by iceberg scouring, which are available for good attachment of sponges. Once 'pioneer' sponges attach to the rocky substrate and gravel lag deposits of the iceberg furrows, later sponges may colonize by attaching to the skeletons of dead sponges (Krautter *et al.* 2001).

Hexactinellids are not known to anchor to muddy or sandy seafloor sediments (Conway *et al.* 1991). Specific oceanographic conditions are also important in development of the reefs. Tidal currents are typically 0.15 – 0.30 m/s and are focused by bathymetry of the troughs, where the reef complexes are found and where seasonal summer upwelling and relaxation of downwelling allows nutrient rich slope water to nourish the reefs. Although these species are not rare in BC, it has been suggested that their unique occurrence as reef-building colonies in the region is associated with the high levels of silicates found in the fjords and heads of canyons (Austin 1984, 1999).

It should be noted that the life cycles of the sponge species in question are largely unknown. Larval stages are unidentified to date and little is known juvenile settlement, growth, and recruitment. Also unknown is the persistence of hexactinellid skeletons after death. This is critical to the continued persistence of the reefs themselves, as the larvae use existing sponge skeletons as an attachment substrate.

7.2 Impacts of Fisheries on Sponge Reefs

Sponge reefs have been negatively impacted by fisheries activities. The most significant fishery from this perspective is the groundfish bottom trawl, although groundfish hook and line, shrimp trawl, and crab trap fisheries are also active in the region and may also impact the reefs.

Bottom trawling activities of various fisheries are known to damage sponge reefs, principally through breakage and removal of the living sponges from the reef surface. Side-scan sonar observations revealed evidence of increasing trawl damage on the Reef D between 1988 and 1999 (Conway 1999). The groundfish trawl fishery has heavily impacted or destroyed about 50% of the known sponge reef areas. Some individual trawl tows have bycatch of 6,000 kg of sponges (K. Conway, pers. comm.). Secondary impacts may occur through lowered recruitment rates of new sponges or through interference with the filter-feeding activities of these species. Recovery time for damaged reefs has been estimated at between 50 to 200 years (Conway 1999, Conway *et al.* 2001).

Sponge catch per unit effort (CPUE) was estimated for the period 1996-2001 for Reefs C and D, and was estimated to comprise about 15% of the total catch during this period for trawl events taking place directly over the reefs. Percentages declined for trawl activity in areas immediately adjacent to the reef, but still represented over 6% of the total CPUE (Jamieson and Chew 2002). The greatest trawling activity has been recorded for Reef D.

Other fisheries may also damage the reefs. As with the groundfish hook and line fisheries, many of the deep-water trap fisheries in the region attach traps to longlines. When gear of either type is hauled up, they may be pulled along the bottom for considerable distances, which may break sponges (Jamieson and Chew 2002).

Sponge reefs provide structural complexity which may represent high-quality habitat for various fish species, particularly juveniles. Thus sponge reef damage may have cascading effects on demersal fish assemblages through loss of refugia for juveniles. This may be of particular importance to rockfish species, which are known to have suffered population declines in recent years (Anon. 2002). Cloud sponges (*Aphrocallistes vastus*) appear to be important nursery areas for small fish (Harbo 1999).

7.3 Current Status

The shrimp trawl fishery implemented a voluntary closure at reef sites, as jointly requested by Shrimp Trawl Sectoral Committee, the Pacific Coast Shrimpers' Cooperative Association, and DFO (DFO 2000). In 2002, DFO closed the area around the five known sponge reef complexes to groundfish trawl fisheries (DFO 2003). However trap (lingcod/ crab/prawn) and longline (halibut/rockfish) fisheries still operate in the area (DFO 2003.). However, as the extent of the reefs was poorly known at the time of the creation of these closure areas, a number of the reefs approach the edge of the fishery closure lines, creating the potential for further trawl damage to the reefs (Jamieson and Chew 2002). In response, the Pacific Scientific Advice Review Committee (PSARC) Habitat Subcommittee formally recommended, as an interim measure, the creation of 9 km buffer zones circumscribing the known extent of each reef (PSARC 2002). Jamieson and Chew (2002) argued that Marine Protected Areas would offer the most comprehensive protection of these sites in terms of conserving the functional integrity of these reefs. They further recommended that research and monitoring programs be initiated to evaluate the importance of the reefs to the overall shelf ecosystem.

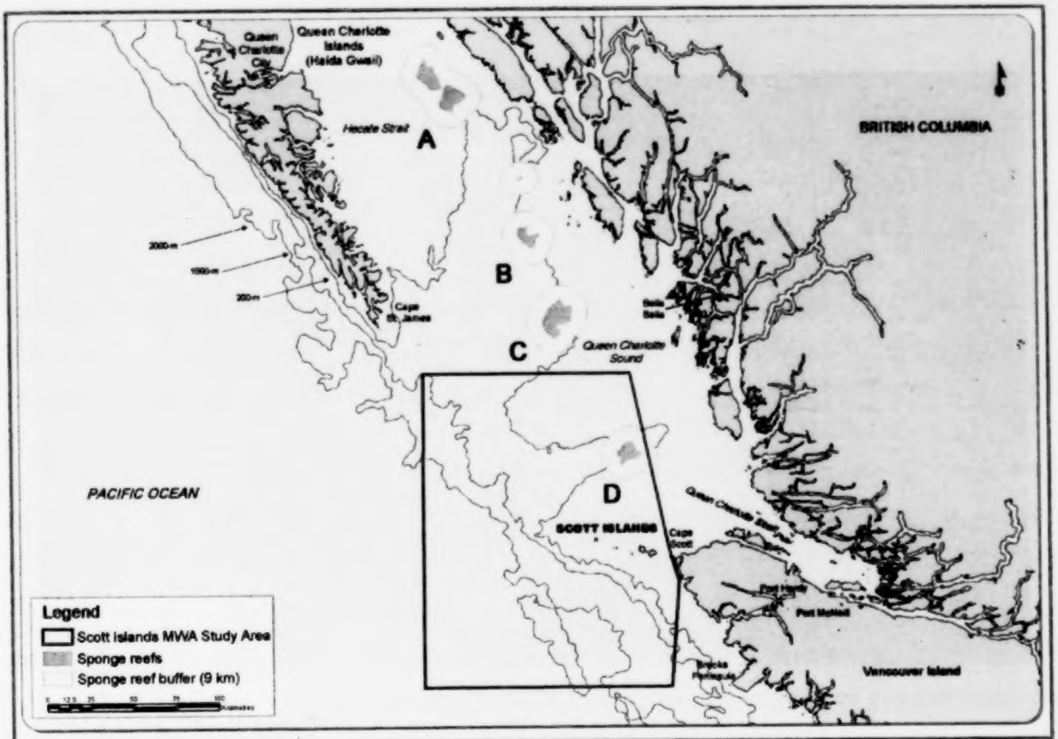

Figure 7-1 Hexactinnelid sponge reef locations, with suggested 9 km buffer zones, in the Hecate Strait and Queen Charlotte Sound

Data Source: Natural Resources Canada - Geological Survey of Canada

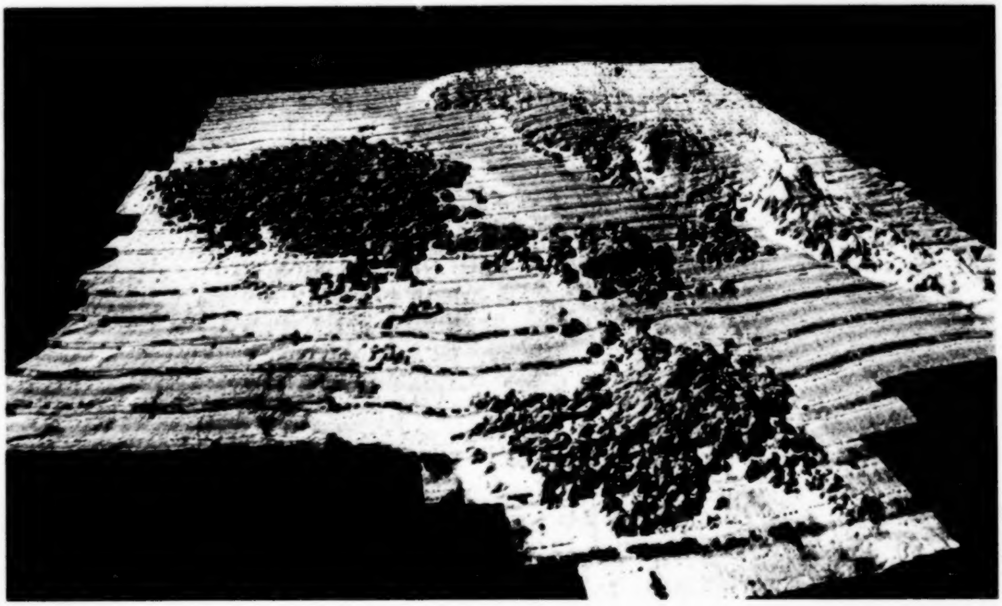

Figure 7-2 Sponge reef backscatter images for Reef D.

Data Source: Natural Resources Canada - Geological Survey of Canada

Canadä

8. Threats

8.1 Fisheries

8.1.1 Seabird bycatch

8.1.1.1 Introduction

Seabird bycatch in commercial fisheries represents a potential threat to seabirds utilizing the Scott Islands MWA study area. Seabirds may be negatively impacted directly through mortality from longline and net fisheries (Brothers *et al.* 1999; Tasker *et al.* 2000; Smith and Morgan 2005). However, a lack of research and monitoring effort was identified for British Columbia with respect to the population impact of seabird bycatch (Smith and Morgan 2005).

8.1.1.2 Longline Fisheries

A number of seabird species have been identified as vulnerable to bycatch in longline fisheries. The Black-footed Albatross(*Phoebastria nigripes*) makes foraging trips from Hawaii to the shelf break along the west coast of North America during the breeding season (Hyrenbach *et al.* 2002), where it overlaps with various demersal and pelagic longline fisheries. This species has recently been upgraded to globally Endangered on the basis of a projected future decline of more than 60% over the next three generations (56 years), taking account of present rates of incidental mortality in longline fisheries in the North Pacific Ocean (IUCN 2003a). The Black-footed Albatross is the most commonly reported seabird bycatch species in the British Columbia longline fisheries (K. Morgan, unpubl. data). Wiese and Smith (2003) conservatively estimated that between 58 and 223 were killed annually in BC longline fisheries. The Short-tailed Albatross (*P. albatrus*) (Vulnerable - IUCN) has recently been designated Threatened nationally (COSEWIC 2003a), due primarily to the potential threat of incidental bycatch in longline fisheries in British Columbia. No bycatch of this species has yet been reported in British Columbia waters. The Laysan Albatross (*P. immutabilis*) has recently been designated Vulnerable globally, due to a projected >30% population decline over the next three generations (84 years) attributable to longline fisheries mortality in the North Pacific (IUCN 2003b). Although there are currently no reported bycatch records of Laysan Albatross in British Columbia, it is the most common albatross species caught in Alaskan groundfish fisheries (Melvin *et al.* 2001). Other species caught in British Columbia longline fisheries include Northern Fulmar (*Fulmarus glacialis*), Sooty Shearwater (*Puffinus griseus*), Glaucous-winged Gull (*Larus glaucescens*), Herring Gull (*L. argentatus*) and California Gull (*L. californicus*) (K. Morgan unpubl. data, Smith and Morgan 2005).

8.1.1.3 Net Fisheries

Currently, there are insufficient data to assess the overall level of seabird mortality due to net fisheries in British Columbia (Smith and Morgan 2005). However, in British Columbia gillnet and seine test fisheries, seabird bycatch rates ranged between 0.019 and 0.108 birds per hour fished. Common Murres (*Uria aalge*) were most commonly caught (87 % of total seabird bycatch in one test fishery), but Rhinoceros Auklet (*Cerorhinca monocerata*) also represented a high proportion of the seabird bycatch. Other species caught in gillnets included Marbled Murrelet (*Brachyramphus marmoratus*; COSEWIC – Threatened), Ancient Murrelet (*Synthliboramphus antiquus*; COSEWIC – Special Concern), Sooty Shearwater, loons (*Gavia* spp.), and cormorants (*Phalacrocorax* spp.). Common Murres are a particular conservation concern within the Scott Islands MWA study area, as recent studies have suggested an apparent population decline at the Triangle Island colony. This possible decline may be linked to mortality from fisheries bycatch (M. Hipfner, pers. comm.). To investigate this hypothesis, CWS staff is planning to assess population and demographic trends of murres at all known colonies, including Triangle Island (M. Hipfner, pers. comm.). Currently, there are no active gillnet or seine fisheries within the Scott Islands MWA study area, although seabirds breeding in the area, such as the Common Murre, may overlap with net fisheries in the non-breeding season.

Trawl fisheries in British Columbia also have the potential to contribute to seabird mortality. Birds are attracted to the offal from fish processing or discards discharged behind the vessel, and may become entangled in the trawl net while it is being hauled back in. Although a rare event, seabird bycatch does occur in BC. To date, the only reported seabird mortality in BC trawl fisheries was that of a Short-tailed Shearwater (*Puffinus tenuirostris*) caught in a midwater trawl, in area 3C (southwest coast of Vancouver Island) (K. Morgan, unpubl. data). Observer coverage in the trawl fisheries has been 100% since 1996. However, seabird bycatch may go unnoticed by observers, depending on how they estimate total catch. Consequently, Smith and Morgan (2005) recommended that the bycatch of all trawl fisheries in BC waters needs to be assessed.

8.1.1.4 Factors influencing seabird bycatch rates

In the demersal longline fisheries, seabird mortality occurs when birds become hooked and drown while attempting to grab baited hooks set behind the moving vessel. A number of relatively inexpensive seabird bycatch avoidance devices have been developed, including hook or line weighting, streamer devices, and buoy bags. Melvin *et al.* (2001) found that bird streamers effectively reduced seabird bycatch by 70-90 %. Longline vessels licensed to catch halibut in BC haul up to 8 million hooks annually. In 2002, the DFO made the use of seabird avoidance devices a mandatory condition of licensing for halibut boats longer than 30 feet. In the same year the rockfish hook and line fishery, which sets 3 to 4 million hooks a year, adopted similar seabird avoidance measures. Currently, all groundfish hook and line fisheries require use of seabird avoidance devices as a condition of license. Starting in 2004, DFO increased compliance monitoring of use of seabird avoidance devices in these fisheries, primarily through refinements of existing air surveillance methods. However, it should be noted that, because violations are difficult to detect (vessels must be observed while hooks are actually being deployed), it has so far proved difficult to enforce the new regulations (S. Bunten, pers. comm.).

Observer coverage in the past has been relatively low (10.5% coverage in 2002 for the rockfish fishery, and 18.5 % coverage in the halibut longline fishery), which may have lead to difficulties in assessing the efficacy of these new measures. However, in the groundfish fisheries including the halibut fisheries, DFO has since committed to implementing mandatory 100% at-sea monitoring in 2006 (DFO 2005). Except in limited cases where vessel-specific technical limitations require human observers, at-sea monitoring will be implemented using electronic monitoring devices.

Gillnet fisheries are under increasing pressure to be more selective, and reduce the bycatch of non-target salmon species, marine mammals and other bycatch, including seabirds. A number of devices designed to reduce seabird mortality, including drop weedlines and high visibility panels have been tested in British Columbia. Drop weedlines, developed to eliminate bycatch of non-target salmon species such as steelhead (*Oncorhynchus mykiss*), consist of a 1-2 m net-free area, directly below the corkline. Some have suggested that the device may also reduce seabird bycatch; however, such devices may in fact have the opposite effect. A seabird, seeing only unobstructed water when it first begins its dive, may subsequently become entangled in the unmodified net further below (Smith and Morgan 2005). In a study conducted in Washington State, high visibility panels placed in the upper 20 to 50 meshes (where bird entanglement is most common) resulted in declines in seabird bycatch rates, without reducing the catch of the target species (Melvin *et al.* 1999). In this fishery, avoiding sensitive times and locations may be more effective. For example, a number of test fisheries reported that seabirds were caught with the greatest frequency in nets sets at dawn or dusk (Melvin *et al.* 1999, Smith and Morgan 2005). At present, however, no seabird bycatch avoidance devices or regulatory measures have been implemented.

Temporal overlap between fisheries and seasonal seabird distributions, including proximity to seabird colonies, should also be taken into account (Smith and Morgan 2005). For gillnet and seine fisheries, foraging seabird distributions are expected to overlap most extensively with fisheries activities from April to September. In demersal longline fisheries, the following areas and times are of concern: mid-March to mid-June for Queen Charlotte Sound, Goose Island Bank, Scott Islands, and Cape St. James, and mid-June to mid-September along the west coast of Vancouver Island.

8.1.2 Marine Mammal Bycatch

Mortality of marine mammals, including Dall's Porpoise, Harbour Porpoise, and Pacific White-sided Dolphin (SAR 2000d-h) has been documented in U.S. fisheries, and observed in BC waters as well (K. Morgan, unpubl. data). Marine set gillnet fisheries were specifically identified for Harbour Porpoise (SAR 2000f). However, currently these impacts appear to be low (a few individuals/year for each species) and are not thought to be ecologically significant (Gregr 2003). Pinnipeds such as Harbour Seals and sea lions also occasionally become entangled in fishing nets and drown, although this is not thought to represent a population-level threat (Olesiuk and Trites 2003). Sea Otters may also be negatively affected by fisheries through entanglement in fishing gear. The impact of fisheries on Sea Otters in British Columbia is currently unknown, but potential Sea Otter-fisheries interactions are likely to increase as the population continues to expand into areas of gill-net fisheries (Sea Otter Draft Recovery Strategy 2002).

8.1.3 Non-target fish bycatch and fisheries over-harvest

Targeted trawl and longline fisheries catch many non-target fish species as bycatch. These fish are discarded back into the ocean when there is no market for the non-target species, they are of less value than the target species, or their retention would exceed the permitted limits. Some species, particularly rockfish (*Sebastes sp.*), sustain lethal physiological damage due to the effects of sudden pressure change (Yamanaka and Lacko 2001). Mortality rate of discarded rockfish is thought to approach 100%. With the exception of rockfish and halibut, mortality rates of other species are not based on actual research, although they are probably associated with depth, time of capture, and condition at capture (PFMI 2003). Knowledge of true fishing mortality rates is required to generate accurate knowledge of stock status, from which Total Allowable Catch (TAC) is generated. It is also difficult to ensure that catches are kept within the TAC when discard mortality is not deducted (PFMI 2003).

Depending on the type of fishing license, many vessels are prevented from retaining non-target commercial bycatch species (DFO 2003). However, some fisheries, such as the halibut fishery, allow for the retention of a proportion of the rockfish bycatch (DFO 2004b). In recent years, the groundfish trawl industry has recognized that at-sea release of non-target species represents a serious conservation concern, and has implemented an Individual Vessel Quota (IVQ) system to allow for the full utilization of harvestable stocks and reduce bycatch impacts (DFO 2003).

Many commercial fish species have been harvested beyond sustainable levels in the past, and suffered subsequent population declines. Although fisheries resource management has improved, it has been generally acknowledged that many TAC's are based on incomplete and inadequate science (i.e. biological studies, survey data, and fisheries data) (PFMI 2003). For example, there is now considerable evidence of declining stocks of inshore rockfish species due to unsustainable levels of fishing effort in commercial and recreational fisheries. Declines were not identified at an earlier stage due to a lack of fishery-independent abundance estimates (Yamanaka and Lacko 2002).

8.1.4 Impacts of fisheries on important seabird forage species

Fishing activities may reduce the abundance of critical seabird forage species directly (target fisheries) or indirectly, through bycatch (Tasker *et al.* 2000). Trawl fisheries may also alter or destroy seafloor habitat structure, resulting in reductions in productivity, abundance, and distribution patterns of forage fish species (Committee on Ecosystem Effects of Fishing, 2002).

A seabird forage species of special concern is the Pacific Sandlance (*Ammodytes hexapterus*), as it is a principal chick provisioning item for both Rhinoceros Auklets and Tufted Puffins (Vermeer 1979), as well as other pelagic birds (Robards *et al.* 1999b). Commercial fisheries of sandlance elsewhere have been linked to seabird population declines (Rindorf *et al.* 2000). Currently, there is no sandlance fishery in the Northeast Pacific. The shrimp fishery in British Columbia has the potential to negatively impact the sandlance population through bycatch, although there has been no significant documentation of this to date (Hay *et al.* 1999). In addition, excessive anchoring and bottom trawling can disrupt the ocean bottom and disturb habitat essential to the life history of this species (Committee on Ecosystem Effects of Fishing 2002). Commercial, but not recreational, vessels are currently permitted to anchor in the waters surrounding the Scott Islands.

A commercial fishery also exists for Pacific Herring, a forage species of substantial importance to Rhinoceros Auklets during years characterized by warmer ocean temperatures, when sandlance availability appears to be reduced (Hedd *et al.* in prep). Intensive fisheries in the 1960's led to a coast-wide collapse of herring populations. Populations have since recovered, although the West Coast Vancouver Island stock has remained in a low productivity state, due predominantly to unfavourable oceanographic conditions (DFO 2002). Important herring fisheries occur at spawning sites in Forward Inlet and Winter Harbour. Breeding Rhinoceros Auklets may be targeting herring in coastal regions when sandlance availability is low (Hedd *et al.* in prep).

8.1.5 Whaling

Baleen whale populations were threatened historically by whaling practices in British Columbia, but commercial whaling in BC waters ended in 1967 (Gregr *et al.* 2000). As a result of whaling activities, most of the great whales were reduced to a fraction of their historical populations from which recovery, here as elsewhere, has generally been slow. In 1986, the International Whaling Committee implemented a moratorium designed to protect whales from all whaling activities; although a small-scale Japanese whaling fishery has resumed in the western North Pacific (Gregr 2003).

8.1.6 Trawl Fisheries impacts on benthic habitat

Bottom-trawling activities may negatively impact benthic environments by crushing and burying benthic organisms, exposing organisms to predation, and by altering sediment and water-column biogeochemistry. Reduction of seabed structural complexity alters benthic ecosystems, removing benthic structures upon which many organisms rely for such activities as feeding and protection from predators. Many juvenile fishes, including commercially harvested species, are associated with small-scale structural features such as rocks, corals, and sponges (Watling and Norse 1998).

The effects of bottom trawling disturbances likely depend on the substrate type and the local natural disturbance regime (Bergman *et al.* 1998; Watling and Norse 1998). In general, shallower nearshore benthic habitats are characterized by regular disturbance events (e.g. wave action generated by storm events). Associated benthic communities are dominated by organisms which are relatively insensitive to disturbance. In contrast, natural disturbance in deep-water environments such as where hexactinellid sponge reefs and deep-sea corals occur, are much less frequent and marine organisms in these habitats are more likely to be extremely sensitive to disturbance. Post-disturbance recovery may take years to centuries in such environments.

8.2 Shipping Traffic

8.2.1 Introduction

The Scott Islands MWA study area experiences moderate to high marine traffic, especially in spring and summer. Vessel types that pass through the region include oil tankers, chemical tankers, cruise ships, cargo ships, fishing vessels, tugs, and cruise ships (Figures 8-1 to 8-5). Threats to biota arising from vessel traffic include risks of catastrophic spills, chronic oil pollution, and the introduction of other pollutants into the marine environment.

8.2.2 Catastrophic Oil Spills

Catastrophic spills from oil tankers and fuel oil from other ships present a threat to marine organisms along the British Columbia coast. Although catastrophic oil spills contribute relatively little to overall global oil pollution, such spills input more oil on a local short term scale than do chronic sources. These events result in acute effects such as the direct mortality of organisms that come in contact with the oil.

Bird mortality from contact with oil is attributable to drowning, hypothermia, the inability to fly or forage, and the ingestion of oil while attempting to preen feathers (Haggarty *et al.* 2003). Alcid species have been identified elsewhere as being particularly vulnerable to oil spills (Wiese 1999, Wiese and Ryan 1999).

Oil spills may also impact marine mammal populations. Seven resident Killer Whales went missing in Alaska shortly after the *Exxon Valdez* oil spill; Loughlin *et al.* (1996) speculated that they may have succumbed to stress from toxic vapours emanating from the spill. In the

Exxon Valdez oil spill, seals and sea lions failed to avoid the oil, and substantial mortality was known to have occurred (Spies *et al.* 1996). Sea lion populations in British Columbia could be significantly impacted if an oil spill occurred near the Scott Islands, as 70 % of sea lion pup production in BC occurs at this location (Olesiuk and Trites 2003). Oil has been identified as 'the single most serious threat to Sea Otter population (Sea Otter Draft Recovery Strategy 2002). Oil destroys the water-repellent characteristics of Sea Otter fur, on which this species relies for thermoregulation. Once fouled, the Sea Otters ingest oil as they groom themselves. Invertebrate prey of the Sea Otters is also vulnerable to oil pollution, and represent an ongoing source of contamination long after the spill event.

Oil spills may also impact fish populations. Acute effects include death or debilitation due to various physical factors. Following the *Exxon Valdez* oil spill, mortality was observed in larval herring as well as a number of sub-lethal effects (premature hatching, low weight, decreased growth, morphological and genetic abnormalities) (Brown *et al.* 1996). Pink salmon exposed to the *Exxon Valdez* oil spill also showed reduced growth in early life stages (Geiger *et al.* 1996, Willette 1996), which may have resulted in a survival reduction of 2% (Willette 1996). Other fish species, especially benthic sole species, as well as walleye pollock (which feeds in the water column) were found to contain metabolites of Polynuclear Aromatic Hydrocarbons (PAH), a toxic component of oil (Collier *et al.* 1996). The longterm impact of oil exposure on physiological and reproductive processes, as well as fish populations, is currently unknown.

Following the Nestucca (1988) and *Exxon Valdez* (1989) spills, the US Pacific States formed, with British Columbia, the Pacific States/British Columbia Oil Spill Task Force. A risk analysis study released as part of a West Coast Offshore Traffic Risk Management Project identified several factors influencing the risk of oil spills. These included distance offshore, risk of collision, traffic density, tug availability, and vessel type (BC MWLAP 2003). Substantial portions of the area of interest for the Scott Islands MWA study area have been identified as being at a higher risk for a number of vessel types, due mainly to the tug response times to this remote area (Figures 8-6 to 8-8).

Although there have been no major spill events in the region, notable incidents have occurred. For example, on February 11-12, 1999 two cargo vessels lost power in high seas off the northwest coast of Vancouver Island and began drifting towards the Scott Islands. At the outset of the emergency, the Canadian Coast Guard anticipated that the vessels would run aground before ocean-going rescue tugs could reach them. Fortunately, rescue vessels were able to reach both vessels in time. The two vessels were reported to be carrying an estimated total of 2,828 tonnes of bunker fuel, and one of the vessels was also reportedly carrying 'dangerous goods' (BC MWLAP 1999).

8.2.3 Chronic Oil Pollution

Although much of the public concern over the impacts of oil pollution has focused on large catastrophic spills, total global spillage from such events is less than that released as illegal discharge due to such activities as removal of dirty ballast water and bilge pumping (Wiese and Ryan 2003). Chronic low-level pollution from such sources might result in reduction in bird populations due either to direct mortality or sub-lethal impacts. Substantial direct mortality as a result of small spills is known to occur in Atlantic Canada (Wiese and Ryan 2003, Wiese and Robertson in press) and elsewhere (Camphuysen and Heubeck 2001). For instance, analyses elsewhere have shown little relationship between the volume of oil spilled and consequent seabird mortality. Instead, spill timing and location are better predictors of seabird mortality (Burger 1993). Sub-lethal effects on organisms exposed to toxic levels of oil pollution over protracted periods also pose a threat to the biota. Although not studied to the same extent as catastrophic spills, sub-lethal effects may have more lasting population impacts (Haggarty *et al.* 2003). These impacts may be realized through a reduction in adult survival (Esler *et al.* 2000), declines in the number of non-breeders, or reduced reproductive success (Ainley *et al.* 1981). Effects such as these have been shown to persist for many years after spill events (Peterson *et al.* 2003). In addition, spawning activities of important forage fish, such as sandlance, may be interrupted or compromised by oil contamination of gravel spawning beds (Pinto *et al.* 1984). Currently, nothing is known of the extent of chronic oiling within the Scott Islands MWA study area.

8.2.4 Cruise Ships

Cruise ships have been identified as a potential source of marine pollution in British Columbia (Nowell and Kwan 2001, Haggarty *et al.* 2003). The number of cruise ships passing through British Columbia waters has been increasing steadily. Currently, over 1 million passengers and crew travel through the central coast region of British Columbia each year (Transport Canada 2003). Waste from cruise ships includes sewage (blackwater), grey water, oil pollution, and hazardous wastes such as dry-cleaning sludge (Haggarty *et al.* 2003). Regulations, monitoring, and enforcement of cruise ships pollution are generally stronger in the

United States than in Canada, which may render Canadian waters more vulnerable to intentional release of pollutants by cruise ships (Nowell and Kwan 2001). Fourteen no-discharge zones have recently been designated in British Columbia, and Haggarty *et al.* (2003) has suggested that sensitive areas within the central coast region be considered for future designation. Although many cruise ships pass through inside waters to the east of the Scott Islands MWA study area, a significant number also use routes that pass directly through this area (Figure 8-3).

8.3 Mammalian Predators

Mammalian predators, particularly rats (*Rattus spp.*), represent a specific threat to colonial nesting seabird populations. Rats have repeatedly been introduced to islands along the British Columbia coast, and are likely to have arrived from disabled vessels or spilled cargo (Harfenist 1994, Kaiser *et al.* 1997). Such introductions have resulted in the destruction/ abandonment of historically active seabird colonies on at least five occasions in British Columbia, and have severely impacted many others (Kaiser *et al.* 1997). Deliberate introductions of mink and raccoon to Lanz and Cox Islands are thought to have resulted in the extirpation of breeding seabirds at both locations. Suitable breeding habitat is available to the seabirds, particularly Cassin's and Rhinoceros auklets on Lanz and Cox islands but use of these islands for nesting are likely hampered by the presence of introduced mink and raccoons. Breeding surveys of Lanz and Cox islands have not been carried out since 1987, at that time suitable breeding habitats did exist and there was evidence of nesting attempts by seabirds. There was evidence of burrow use but no active nests were detected at that time. Strong evidence suggested that the seabirds attempting to nest at these sites were taken by raccoon or mink. Based on the suitable habitat available it could reasonably be assumed that Cassin's Auklets, Rhinoceros Auklets, Glaucous-winged Gulls, storm-petrels, and Black Oystercatcher would be breeding on Lanz and Cox, these species breed on all of the other Scott Islands and there is some historical evidence that at least some of these species did (Cassin's Auklet and Rhinoceros Auklet) (Rodway *et al. 1990). As a result, a program to remove these introduced predators will be considered.*

The research station at Triangle Island currently adheres to strict protocols to prevent the accidental introduction of mammalian predators by vessels delivering equipment and supplies to Triangle Island (CWS Unpublished Report).

8.4 Offshore Oil and Gas Exploration

8.4.1 Introduction

Recent declines in fishing and logging industries in coastal communities have resulted in increased interest in lifting the federal and provincial moratoria on offshore oil and gas exploration (O' Connor 2001). A number of petroleum companies (Shell, Chevron, Petro-Canada, and Exxon Mobil) hold oil and gas tenures in the region (Figure 8-9). Recently, a Royal Society of Canada Expert Panel, in a report to Natural Resources Canada, has concluded that there are no scientific gaps that require filling in advance of a decision to lift the existing moratoria on oil and gas developments. In their report, the panel recognized and outlined many existing gaps in scientific knowledge but argued that, provided an adequate regulatory regime was put in place, this regime would ensure that critical gaps would be filled before development of oil and gas could proceed (RSC 2004).

Exploration and extraction may result in a number of impacts on seabirds, including unnatural congregations around structures such as oil platforms (Wiese *et al.* 2001), effects of seismic testing on forage species distribution, chronic oil pollution, and oil spills. The biological consequences of the two latter types of risk have been discussed in a previous section, so the following sub-sections will address only the additional risks associated with oil-drilling platforms and seismic testing, as well as a discussion of risk levels associated with oil and gas resource development.

8.4.2 Risks Associated with Oil-drilling Platforms

Activities associated with oil and gas resource development invariably increase the risk of oil spills. These include drilling, daily operations, and transportation of oil from the rig via tankers or pipelines. It has long been known that seabirds are attracted to large offshore structures such as oil drilling platforms. The hypothesized causes for this attraction include concentrations of food around the structure (Tasker *et al.* 1986), oceanographic processes around the structure (Fedoryako 1982), light attraction to the structure (Reed 1986), and the potential for the structure to function as a roost site (Montevecchi *et al.* 1999).

Seabirds congregating at offshore platforms may suffer immediate or long-term negative impacts. The intermittent presence of oil in the water around oil platforms may represent a threat through external or internal contact with oil, as discussed above. Also, many seabirds (notably shearwaters, storm-petrels, gulls and alcids) display a marked attraction to artificial lights and flares of oil platforms. Birds have been documented circling oil platforms for days, eventually dying of starvation, flying directly into lights, or too close to flares (Bourne 1979, Reed *et al.* 1985). Mortality from direct contact with gas flares has resulted in large-scale avian mortality elsewhere (Sage 1979). Oil and gas production licenses may stipulate that gas be re-injected into the bottom or stored in reservoirs, rather than being burned at sea (Montevecchi *et al.* 1999).

8.4.3 Seismic Testing

Ship-based seismic surveys of the ocean floor are conducted as part of the first phase of oil and gas exploration to provide a regional picture of geological structure. This is accomplished through an array of 12 to 48 air guns towed behind a vessel together with a string of hydrophones which record the reflected acoustic signals of subsurface geological features. The guns are positioned just below the sea surface, and shots are fired approximately every 25 m while the ship is traveling at a few knots. Initial 2D surveys are used for reconnaissance purposes only. More intensive 3D surveys are required to obtain a complete coverage of the subsurface. Such surveys are likely to be restricted to areas around the most promising hydrocarbon prospects, as they are time-consuming and involve more complex arrays (RSC 2004).

Impacts of seismic surveys revolve around the sound levels emitted by air gun arrays. Sound intensity is not additive, in that an array of guns produces sound at intensities in excess of a single gun, but by less than a factor of the number of guns. Intensity diminishes fairly rapidly with distance from source. Typical frequencies range from 5 -100 Hz, but higher frequencies are produced as well, at lower intensities. Lower frequencies travel the farthest before dropping below ambient noise levels.

Environmental impacts depend on taxon and distance from sound source. A single gun firing with a source magnitude of 232 dB would likely kill all organisms within 1.5 m. Organisms, including eggs and larvae, within 4 m would suffer immediate internal injury resulting in either death or impaired development. Fish or marine mammals may be temporarily stunned at up to 100 m distances (RSC 2004). Fish exposed to a nearby seismic tow (5-15 m distance) have sustained substantial physiological damage to sensory organs (McCauley *et al.* 2000). Post-event survival in the wild of those individuals would be unlikely.

In addition to these physical responses, seismic testing is also known to induce behavioral responses in fish and marine mammals. These responses vary according to species. Some commercially harvested fish species appeared to avoid areas in which seismic shooting was taking place, resulting in substantial declines in trawl catches up to 18 nm distant (Engås *et al.* 1993). In other studies, fish appeared to tolerate fairly high intensity air-gun detonations (Wardle *et al.* 2001, Hassel *et al.* 2003). Marine mammal responses vary from a fair degree of tolerance (e.g. ringed seals; Harris *et al.* 2001) to total avoidance at a distance of over 7 km for bowhead whales (Ljunglblad *et al.* 1985). Very little literature exists for behavioral responses to seismic testing pertaining to species found in the Queen Charlotte Basin. However, nearly all cetaceans use sound for communication and/or echolocation of prey. Currently, there is little information available to evaluate the hypothesis that seismic testing may interfere with either of these activities (RSC 2004).

Whereas extensive field studies on the effects of seismic activity on marine mammals have been conducted, very little information on birds is available. Stemp (1985) failed to document any effect of seismic activities on seabirds, although these data were confounded with seasonal changes in bird numbers related to migration. Stemp (1985) insisted that these results not be extrapolated to areas with large concentrations of feeding or migrating birds, or birds that were molting. Similarly, LaCroix *et al.* 2003 found no effect of seismic activity on movements and diving behavior of molting Long-tailed Ducks in the lagoons of the Alaskan Beaufort Sea. They also cautioned that these results should be evaluated carefully, as logistical and ecological factors limited detection of more subtle disturbance effects. They recommended that additional studies on other bird species to fully understand the effects of underwater seismic testing would be needed.

There is increasing evidence of a causal link between anthropogenic high-intensity sound and multiple-animal strandings, primarily involving the Cuvier's Beaked Whale (*Ziphius Cavirostris*). Reported mass stranding events are relatively rare, but their frequency of occurrence has increased since the 1960's. The timing of this increase coincides with the advent of high-intensity sonar devices. Although a third of multiple-animal strandings have been associated with naval manoeuvres using such devices, two recent instances (Galapagos 2000, Gulf of California 2002) were correlated with seismic surveys in the area (Hildebrand 2002). In the first instance, rudimentary necropsies indicated bleeding from the eyes, a possible indicator of acoustic injury (L. Weilgart, pers. comm.) Although little is known about the life history and population status of this species, Cuvier's Beaked Whales are distributed widely across the world's oceans including the eastern North Pacific (SAR 2000i), and they occur in the waters of the Queen Charlotte Basin.

8.4.4 Exploratory and Production Drilling

There are four main sources of environmental impacts from exploratory and production drilling activities: drilling fluids, discharge of produced water, cuttings, and hydrocarbon discharges.

8.4.4.1 Drilling fluids

Drilling fluids (or 'muds') function as lubricants and coolants during the drilling process. Water-based muds (WBM) are the most commonly used drilling fluid, and are primarily composed of salt water and barite. However, oil-based muds (OBM) may be used during production when directional drilling is required. Diesel fuel is a primary component of OBM and, due to toxicity issues associated with the discharge of diesel fuel, OBM are being replaced by synthetic-based muds (SBM). SBM use synthetic hydrocarbon derivatives such as polyalphaolefins (PAO) or vegetable oil esters (RSC 2004). Toxicity of WBM is generally very low, although they may include biocides, corrosion inhibitors, and surfactants in low concentrations. Although the older OBM contained high PAH content, modern SBM, containing only very low levels of aromatic hydrocarbons, appear to be more chemically benign. However, other non-toxic oils (e.g. canola) still impact birds through degradation of feather integrity, ultimately causing death through hypothermia and starvation (Spies *et al.* 1996). If SBM were to contain such characteristics seabirds, if exposed, may be at risk.

8.4.4.2 Cuttings discharge

Cuttings consist of ground-up rock removed in the drilling process, and they tend to be deposited in close proximity to the drilling operations. Although generally not toxic, these cuttings can smother local benthic communities with large volumes of ground-up rock and small particulate matter. A cuttings 'plume' may be created, the extent of which is a function of the particle size of the cuttings and the local current regime, but can usually be detected up to and occasionally beyond a 5 km radius from the drilling operation (Olsgard and Gray 1995). Impacts of cuttings discharge on benthic communities are generally characterized by major reductions in species abundance and diversity within a few hundred metres of a drilling rig, with a gradual decrease in the severity of the impact with distance from the site.

8.4.4.3 Produced water

Produced water consists of formation waters trapped within the oil deposit. Produced water is usually discharged at sea, though it is technically feasible to re-inject produced water into wells (Wills 2000). Its composition is highly variable, but it may contain significant concentrations of oil. The prevailing view is that produced water, due to dilution effects, will not present any substantial environmental problems when released into a relatively dynamic ocean environment (Patin 1999). However, due to increased concern about contaminant levels in enclosed basins, produced water in the Queen Charlotte Basin will either be removed for offsite disposal or re-injected into the ground (RSC 2004).

8.4.4.4 Hydrocarbon discharge

Hydrocarbon products are separated in the production facility of an extraction platform, and then stored temporarily until they can be transported from the platform by tanker or pipeline. Either mode of transport involves risk of product leakage. Pipeline transport of oil is only feasible for short distances (no more than a few tens of km), although natural gas may be transported over much greater distances. Modern developments in tanker technology have improved spill records (NRC 2003). These include double-hull tankers, dynamic positioning systems, and improved fire protection.

8.4.5 Oil Spill Risk Analysis

Globally, the rate of oil spills from blowouts and daily operations has decreased substantially over the past decade. Blowout frequency estimates were derived from North Sea statistics in the Royal Society Expert Panel Report, as the regulatory framework in these two regions will likely be similar (RSC 2004). The estimated annual rate for spills in excess of 10,000 barrels (1590 m^3) is 10^{-4} (1 in 10,000 operating wells). Although tanker performance has improved substantially between 1985 and 2003 (NRC 2003), absolute risk of a spill would undoubtedly increase in the Queen Charlotte Basin due to heavier tanker traffic in the region.

Should an oil spill occur, its behaviour and trajectory will be factors critical in determining its biological impact. With current modeling capabilities, it is now possible to estimate spill size, spill trajectory, and landfall (Crawford *et al.* 2002), although accurate forecasts of spill behaviour are constrained to a fairly narrow temporal window (i.e. a few days; P. O'Hara, pers. comm.). Behaviour of the oil spill will also depend on type of oil and environmental conditions at time of spill (i.e. wind, waves, and currents). Crawford *et al.* (2002) note that spills in the Queen Charlotte Basin have a greater probability of reaching the shoreline relative to other more exposed regions. Contact with the shoreline would consequently increase environmental impact. However, the extent of this impact will be difficult to predict, due to limited spatial and seasonal distribution data for most species in the region, and represents a significant knowledge gap (RSC 2004).

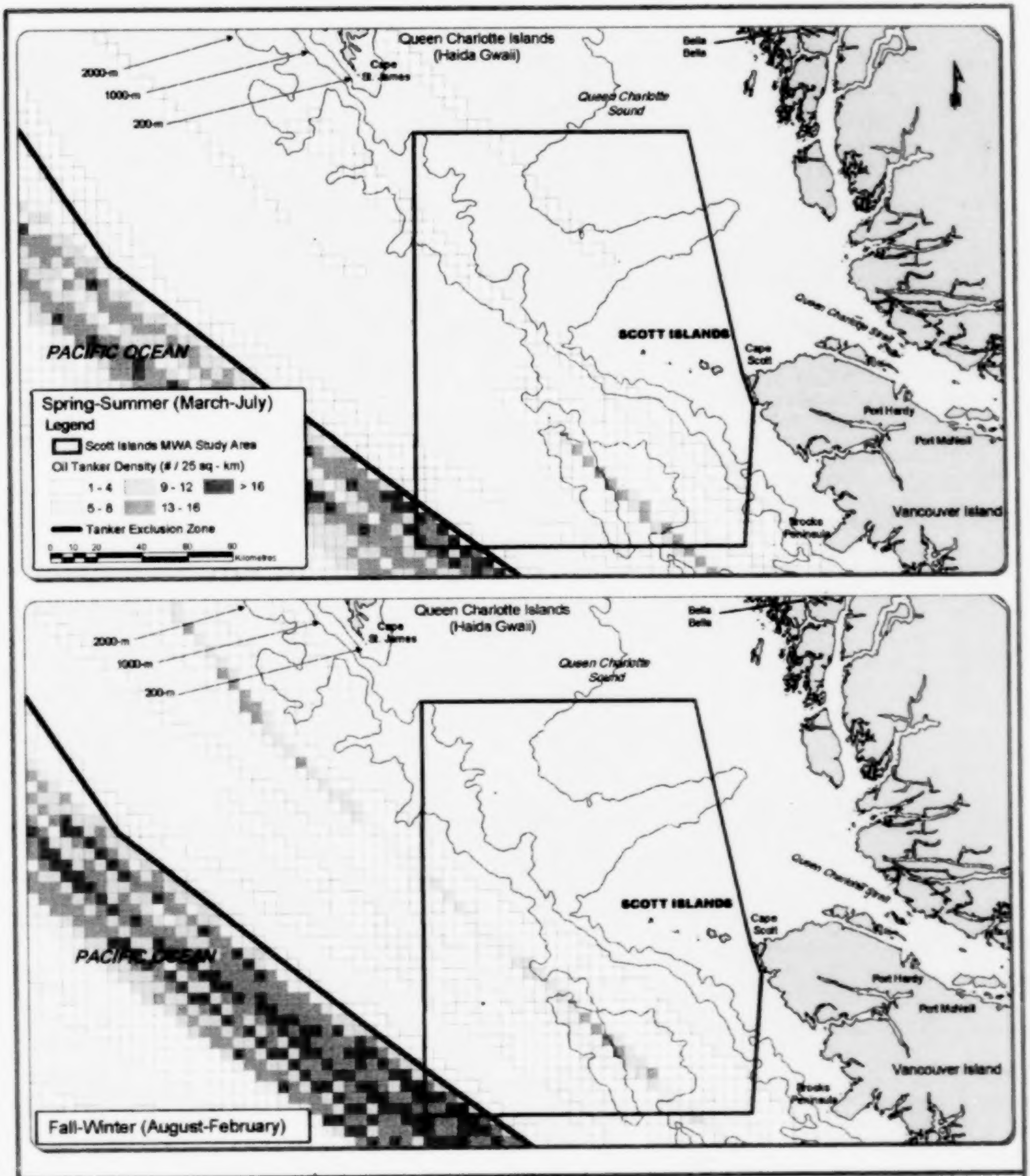

Figure 8-1 Vessel traffic densities in winter and summer for oil tankers in 2003. Summer = 1 March - 31 July, Winter = 1 August - 28 February. Tanker Exclusion Zone is also depicted.

Data Source: Marine Communciations and Traffic Services Vessel Traffic Database.

Canada

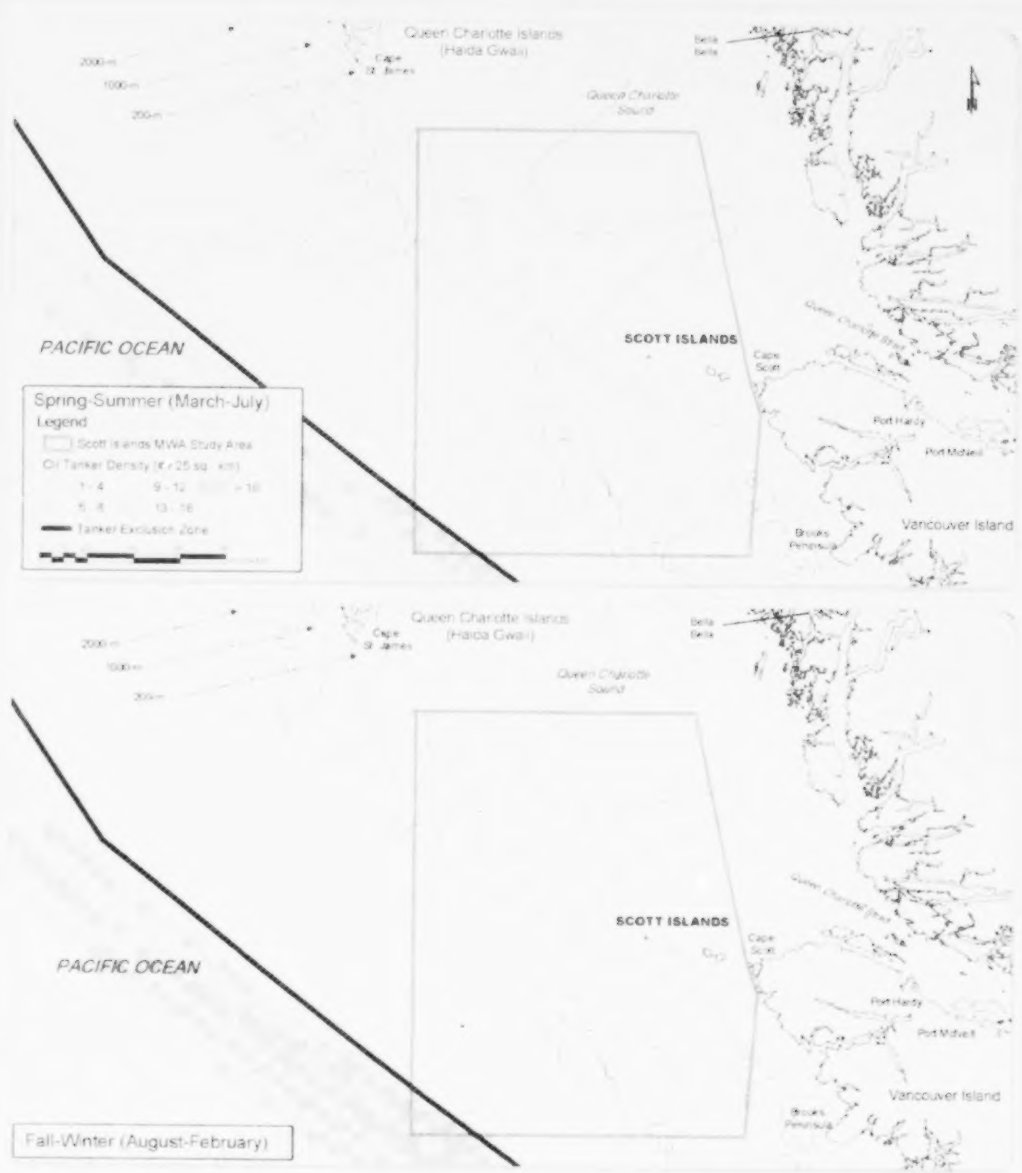

Figure 8-1 Vessel traffic densities in winter and summer for oil tankers in 2003. Summer = 1 March - 31 July. Winter = 1 August - 28 February. Tanker Exclusion Zone is also depicted.

Data Source: Marine Communications and Traffic Services Vessel Traffic Database

Canada

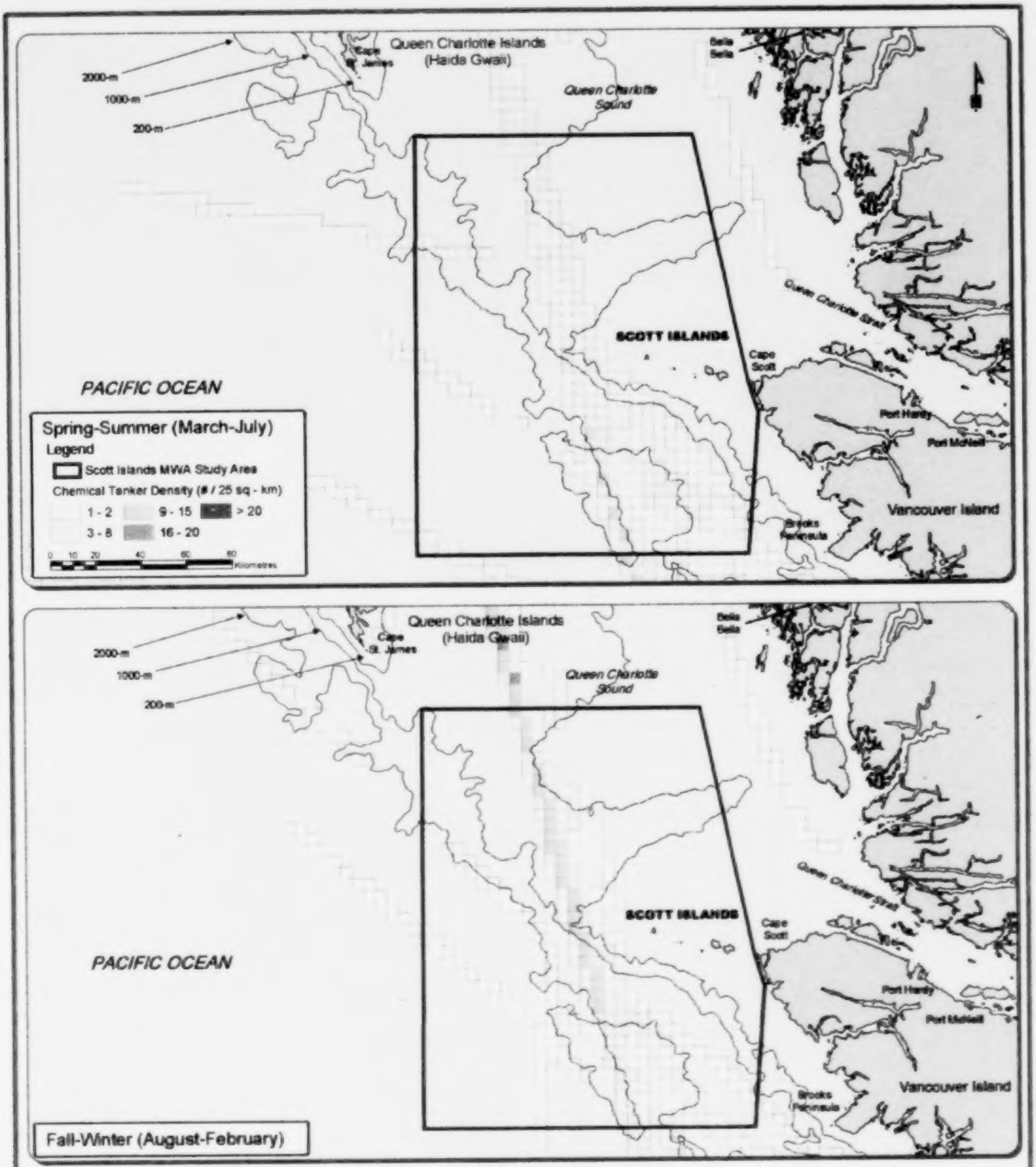

Figure 8-2 Vessel traffic densities in winter and summer for chemical tankers in 2003. Summer = 1 March - 31 July, Winter = 1 August - 28 February.

Data Source: Marine Communciations and Traffic Services Vessel Traffic Database.

Produced by CWS GIS Unit
Date: 20 April 2004

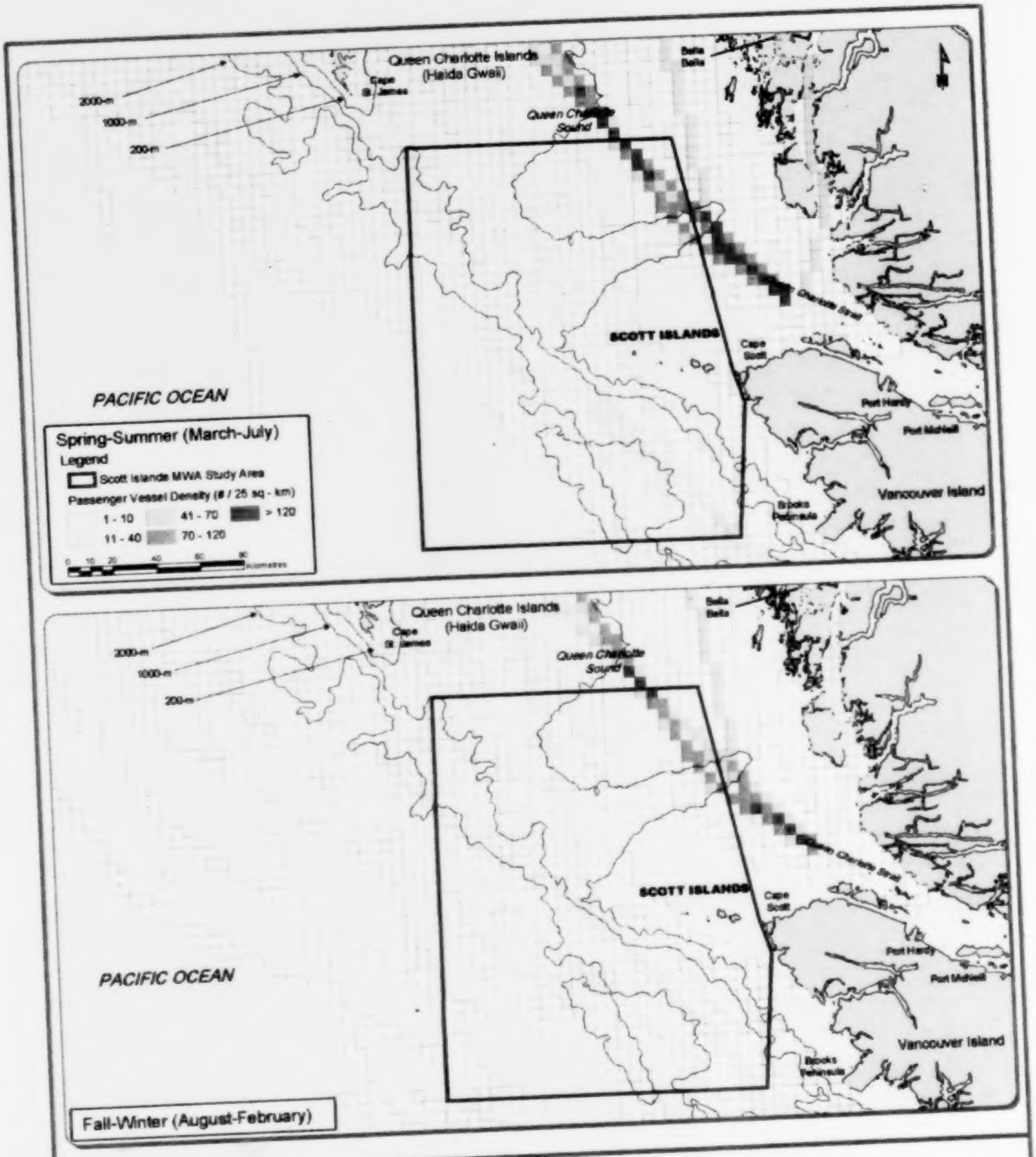

Figure 8-3 Vessel traffic densities in winter and summer for cruise ships and other passenger vessels in 2003. Summer = 1 March - 31 July, Winter = 1 August - 28 February

Data Source: Marine Communications and Traffic Services Vessel Traffic Database.

Canada

Produced by CWS GIS Unit
Date: 30 April 2004

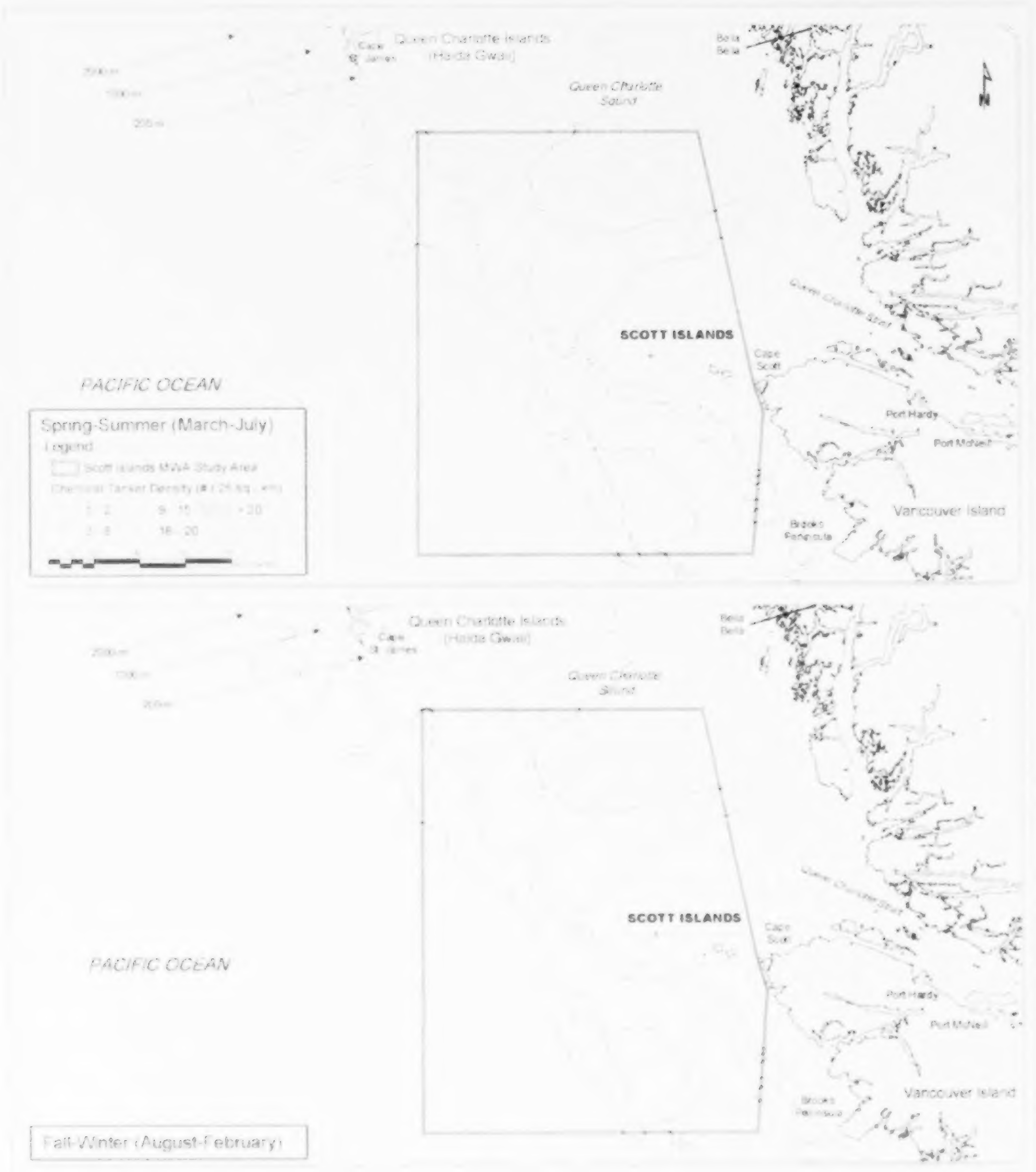

Figure 8.2 Vessel traffic densities in winter and summer for chemical tankers in 2003. Summer = 1 March - 31 July. Winter = 1 August - 28 February.

Data Source: Marine Communications and Traffic Services Vessel Traffic Database

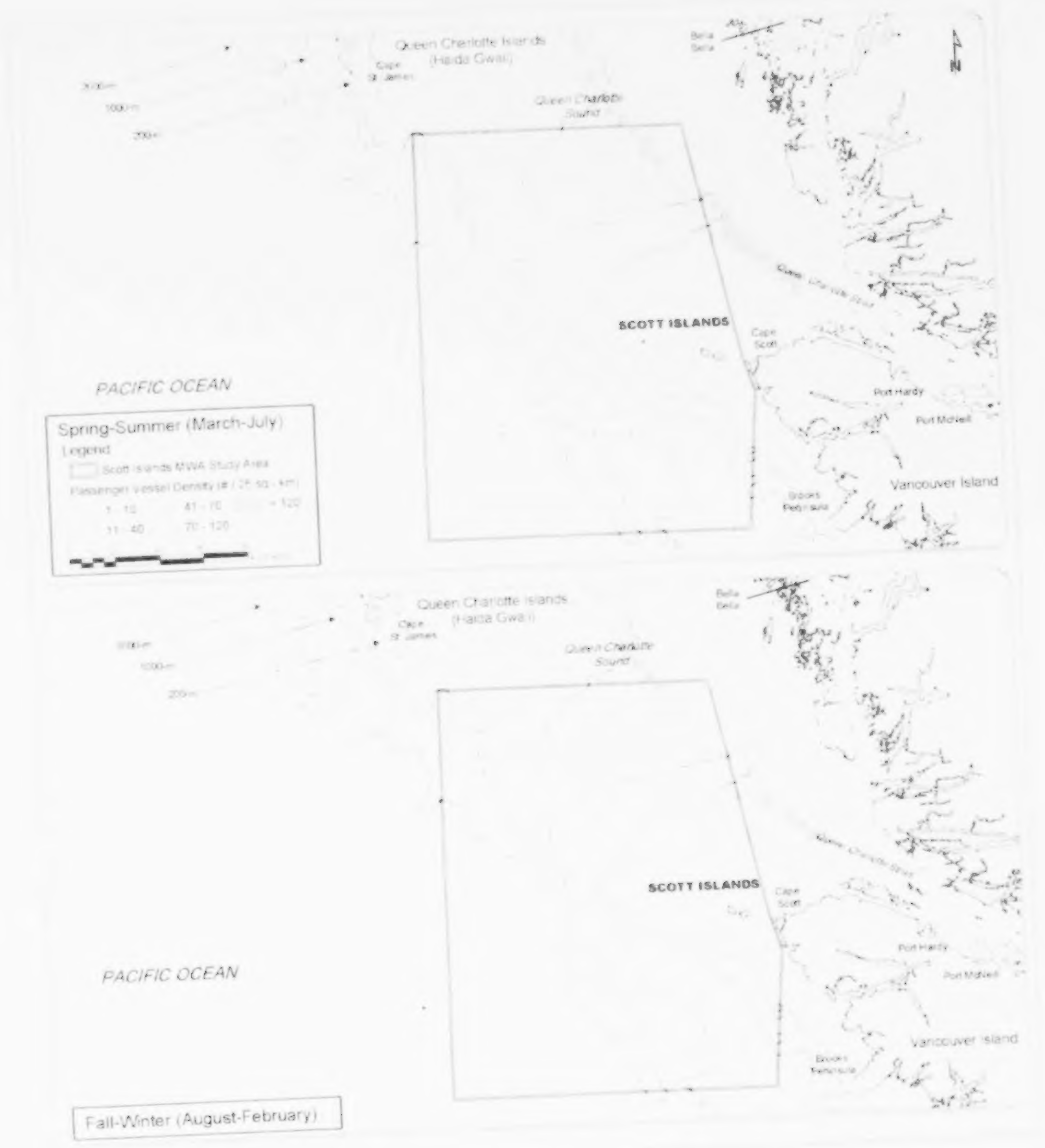

Figure 8.3 Vessel traffic densities in winter and summer for cruise ships and other passenger vessels in 2003. Summer = 1 March - 31 July. Winter = 1 August - 28 February.

Data Source: Marine Communications and Traffic Services Vessel Traffic Database

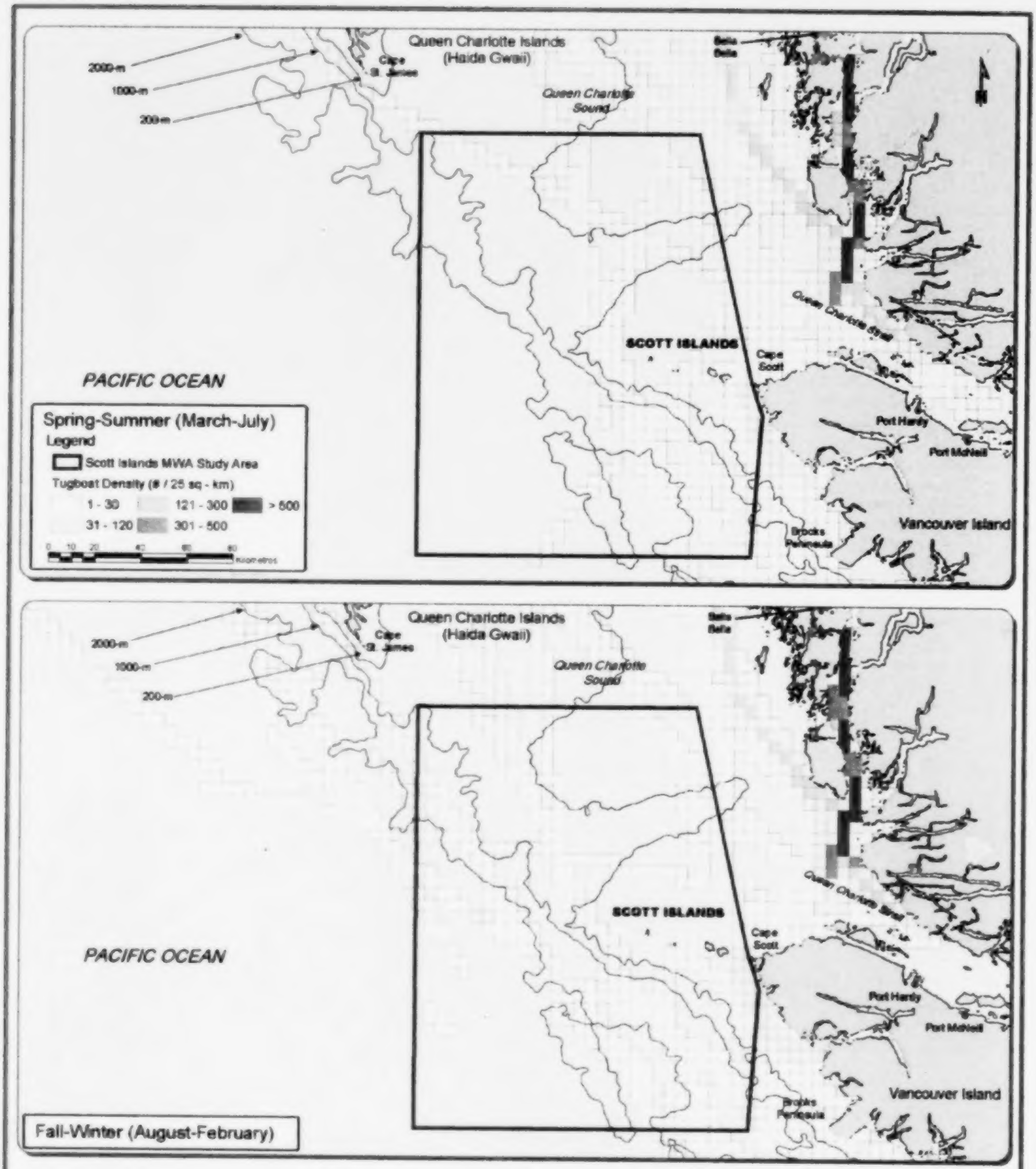

Figure 8-4 Vessel traffic densities in winter and summer for tugboats in 2003. Summer = 1 March - 31 July, Winter = 1 August - 28 February. (Included in the "tugboat" category: tugboats, log carriers and log ships.)

Data Source: Marine Communciations and Traffic Services Vessel Traffic Database.

Canada

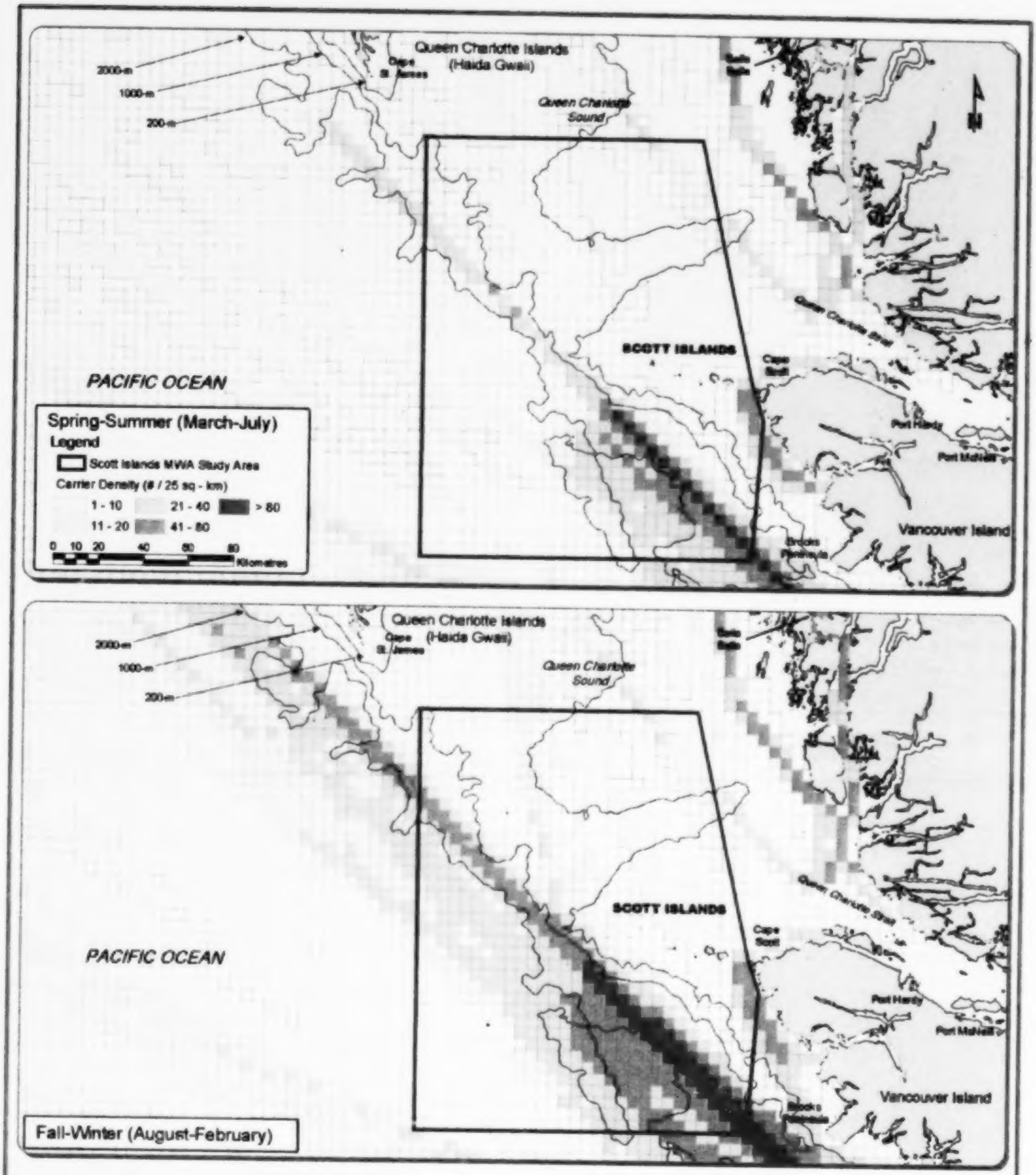

Figure 8-5 Vessel traffic densities in winter and summer for carriers in 2003. Summer = 1 March - 31 July, Winter = 1 August - 28 February. (Included in the "carrier" category: bulk carriers, coastal freighters, container ships, general cargo vessels, ro-ro vessels and other vehicle carriers.)

Data Source: Marine Communciations and Traffic Services Vessel Traffic Database.

Canada

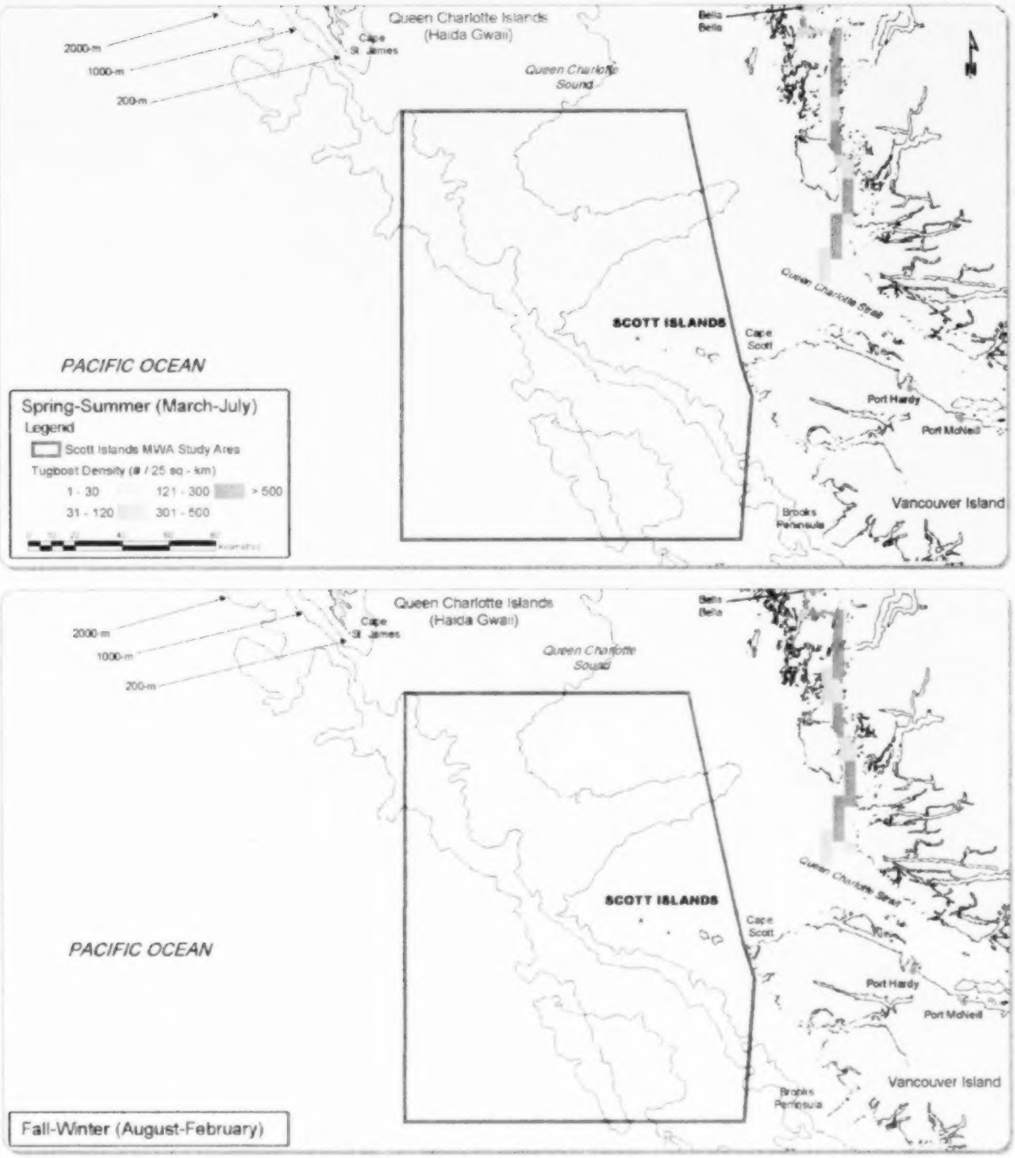

Figure 8-4 Vessel traffic densities in winter and summer for tugboats in 2003. Summer = 1 March - 31 July. Winter = 1 August - 28 February. (Included in the "tugboat" category: tugboats, log carriers and log ships.)

Data Source: Marine Communciations and Traffic Services Vessel Traffic Database

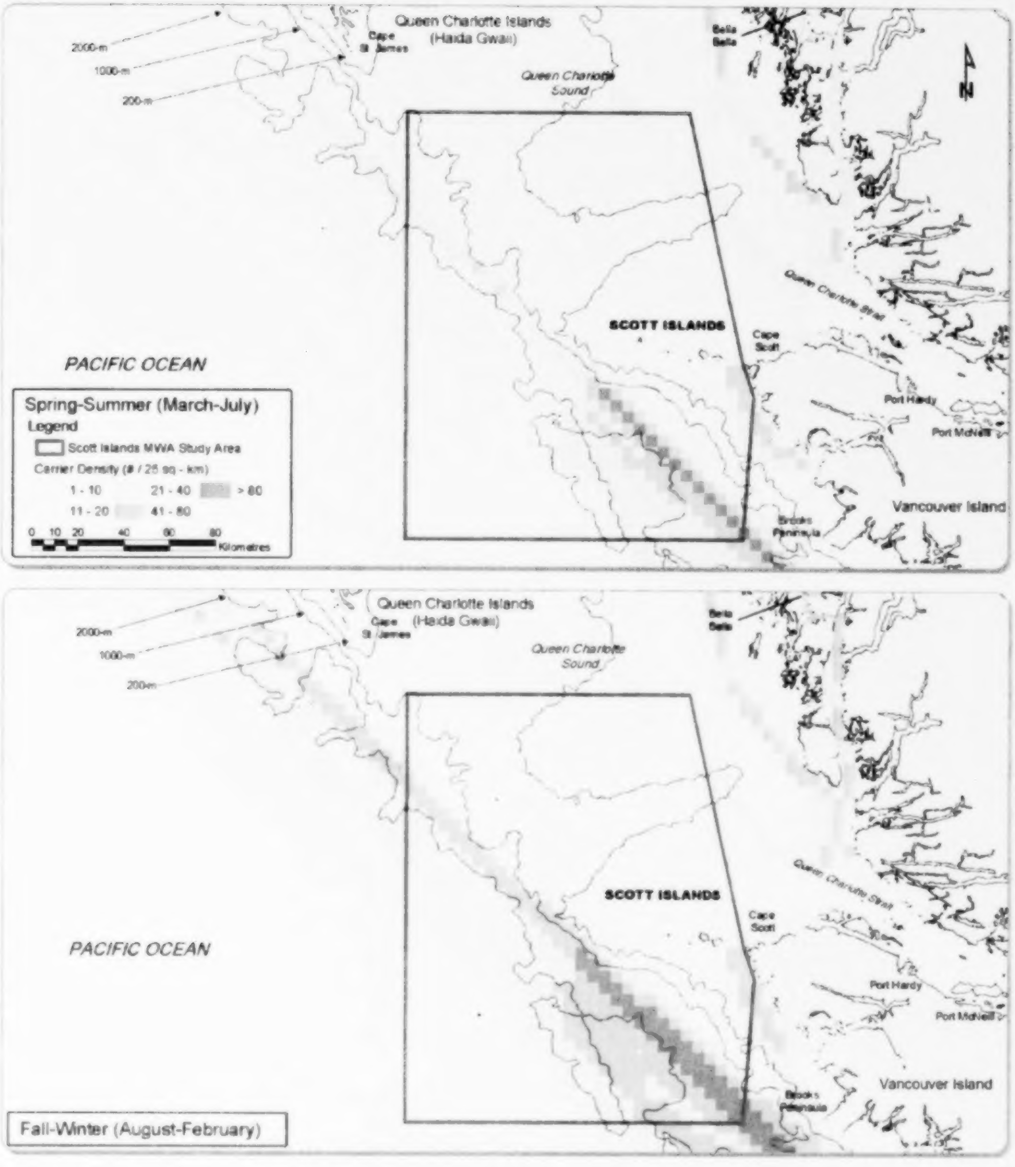

Figure 8-5 Vessel traffic densities in winter and summer for carriers in 2003. Summer = 1 March - 31 July, Winter = 1 August - 28 February. (Included in the "carrier" category: bulk carriers, coastal freighters, container ships, general cargo vessels, ro-ro vessels and other vehicle carriers.)

Data Source: Marine Communications and Traffic Services Vessel Traffic Database

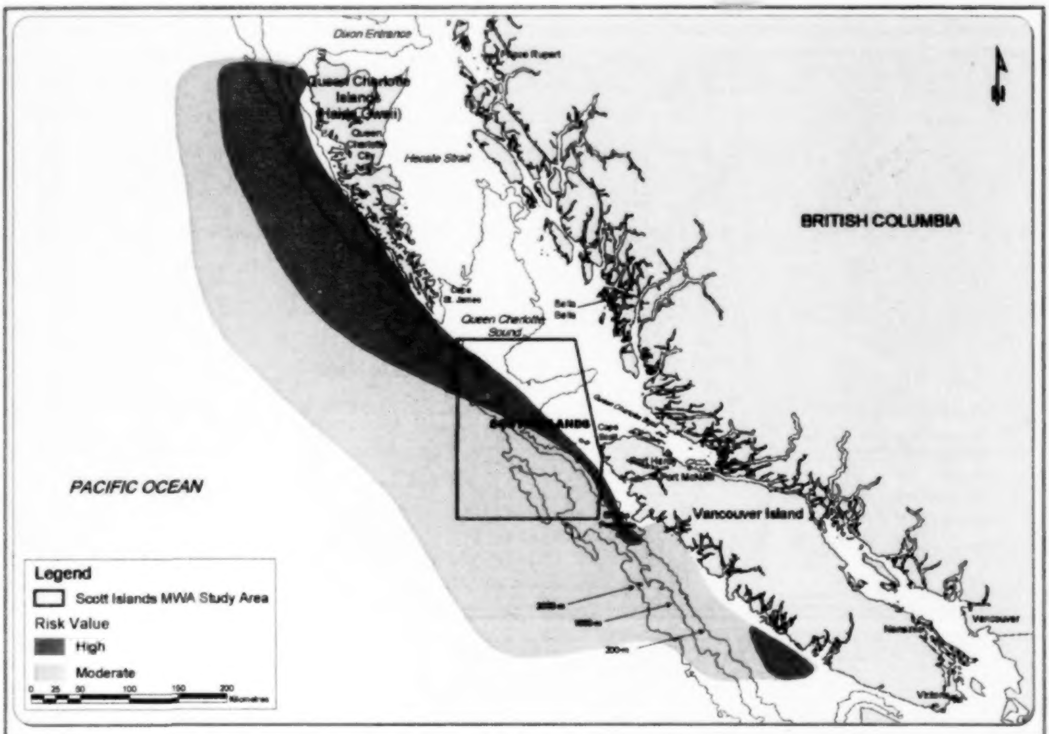

Figure 8-6 Results of a risk assessment model for laden tankers, cargo and passenger vessel traffic off the coast of British Columbia. Red and yellow represent higher and average risk values respectively.

Data Source: West Coast Offshore Vessel Traffic Risk Management Project Final Report, Pacific States/BC Oil Spill Task Force

Canada

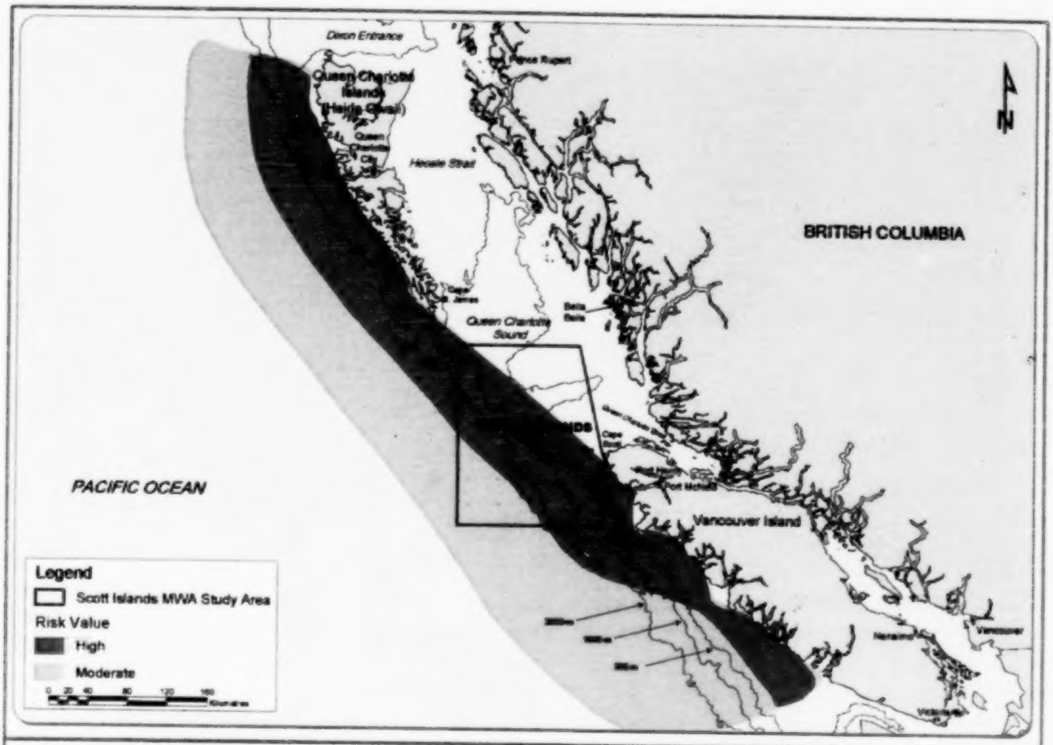

Figure 8-7 Results of a risk assessment model for fishing vessel traffic off the coast of British Columbia. Red and yellow represent higher and average risk values respectively.

Data Source: West Coast Offshore Vessel Traffic Risk Management Project Final Report, Pacific States/BC Oil Spill Task Force

Canada

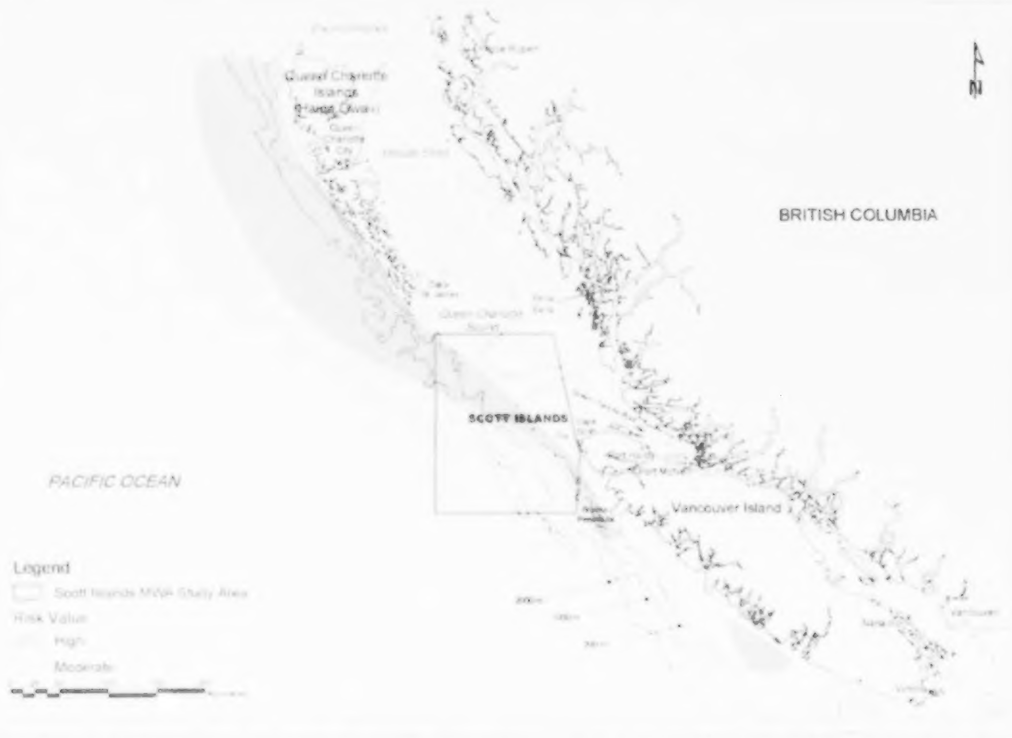

Figure 8.6 Results of a risk assessment model for large tankers, cargo and passenger vessel traffic off the coast of British Columbia. Red and yellow represent higher and average risk values respectively.

Data Source: West Coast Offshore Vessel Traffic Risk Management Project Final Report. Pacific States/BC Oil Spill Task Force.

Canada

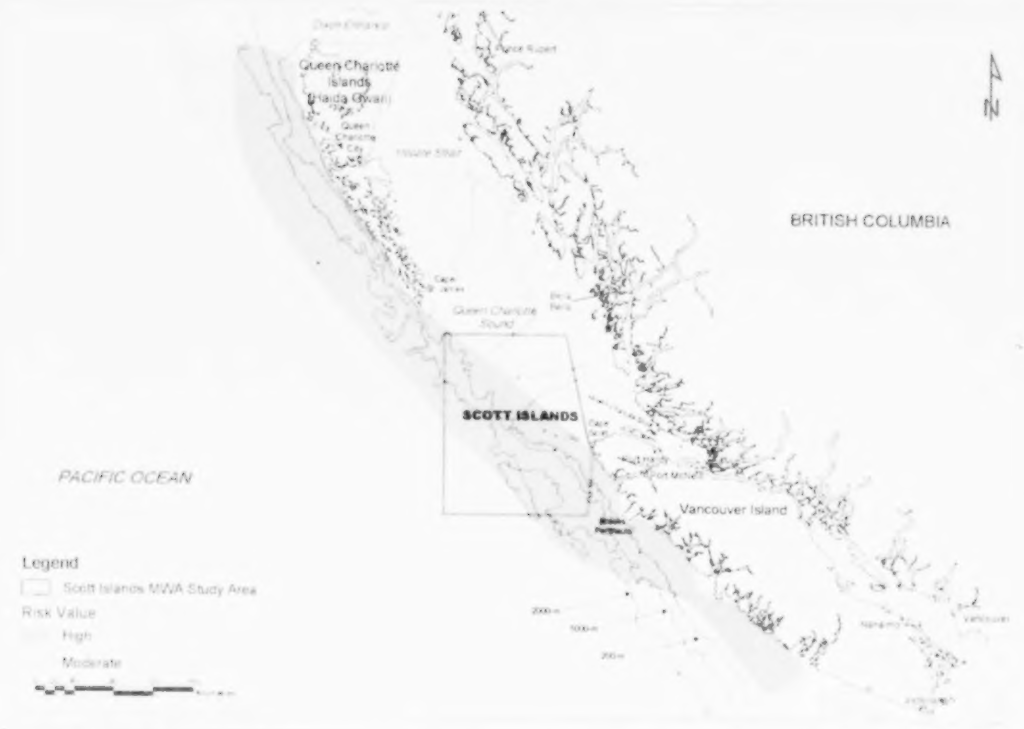

Figure 8.1 Results of a risk assessment model for fishing vessel traffic off the coast of British Columbia. Red and yellow represent higher and average risk values respectively.

Data Source: West Coast Offshore Vessel Traffic Risk Management Project Final Report. Pacific States/BC Oil Spill Task Force.

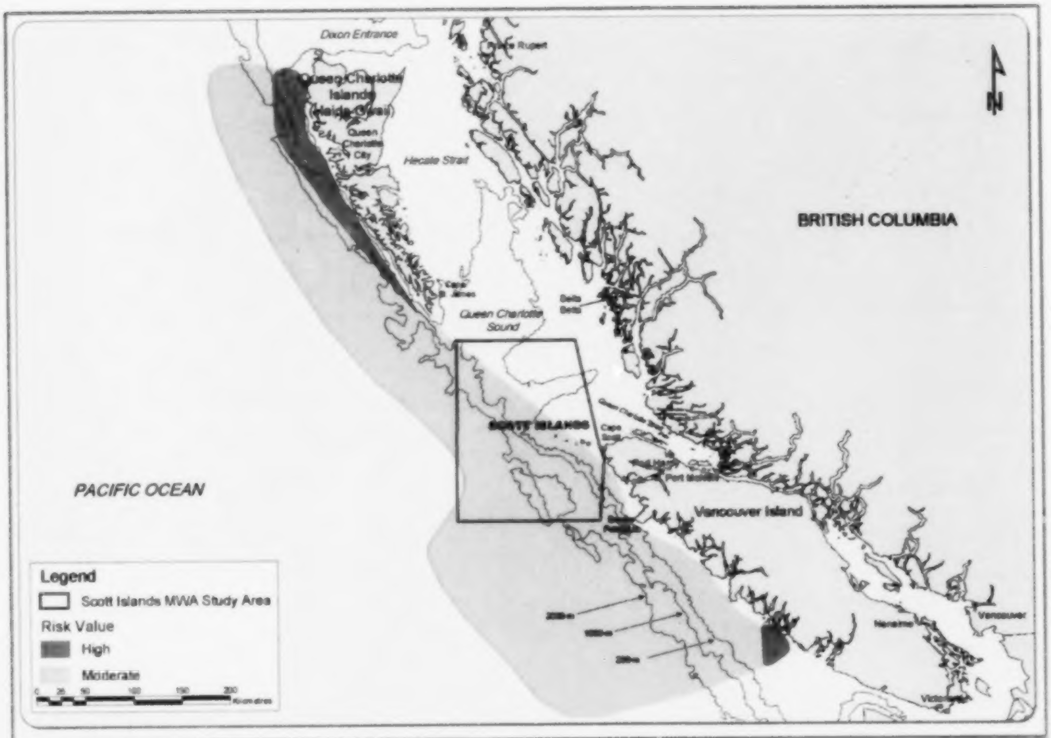

Figure 8-8 Results of a risk assessment model for laden tank barge traffic off the coast of British Columbia. Red and yellow represent higher and average risk values respectively.

Data Source: West Coast Offshore Vessel Traffic Risk Management Project Final Report, Pacific States/BC Oil Spill Task Force

Canada

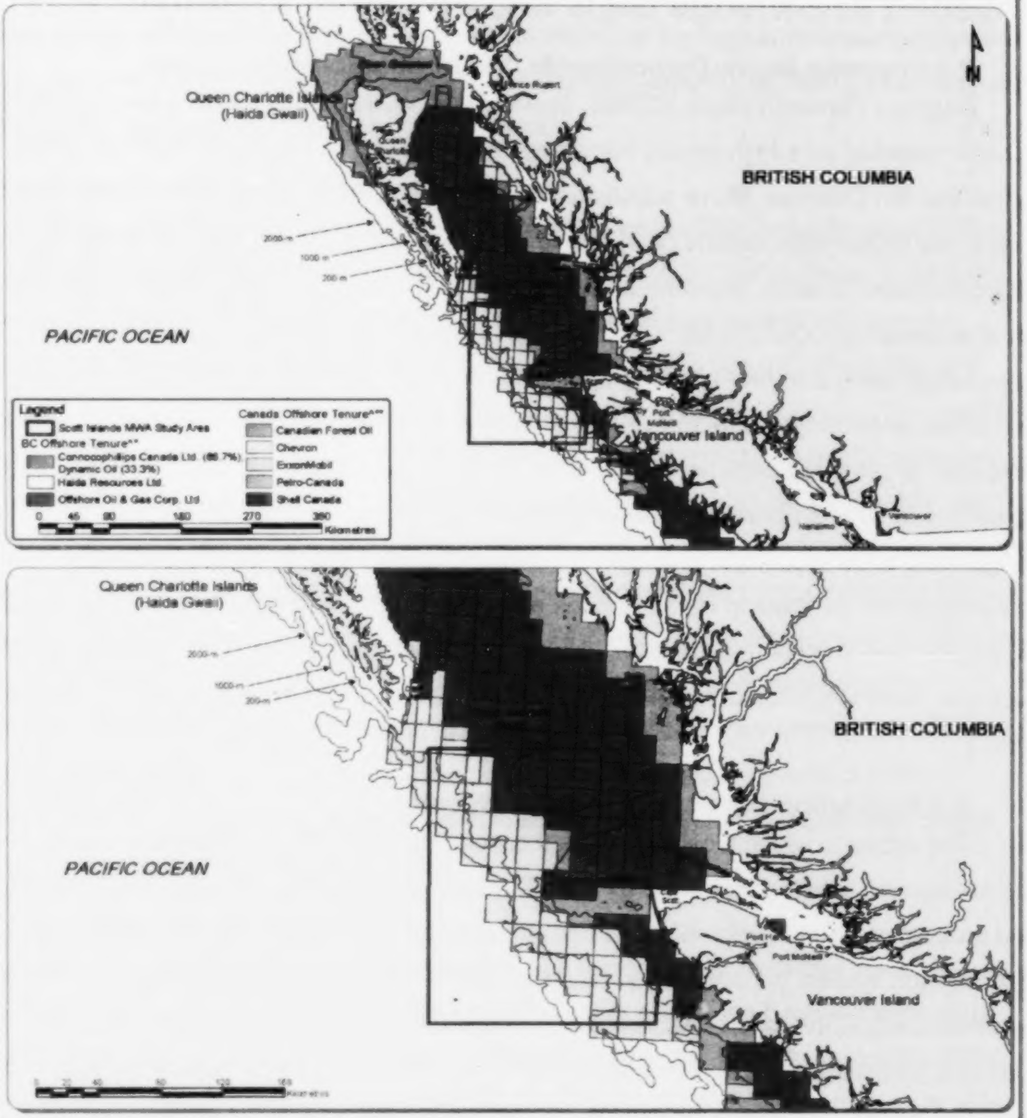

Figure 8-9 Existing BC Offshore Petroleum Tenures

Data Source: Natural Resources Canada

Canada

Queen Charlotte
Islands
(Haida Gwaii)
BRITISH COLUMBIA
Queen Charlotte
Sound
SCOTT ISLANDS
PACIFIC OCEAN
Vancouver Island
Legend
Scott Islands MWA Study Area
Risk Value
High
Moderate
Vancouver
Canada

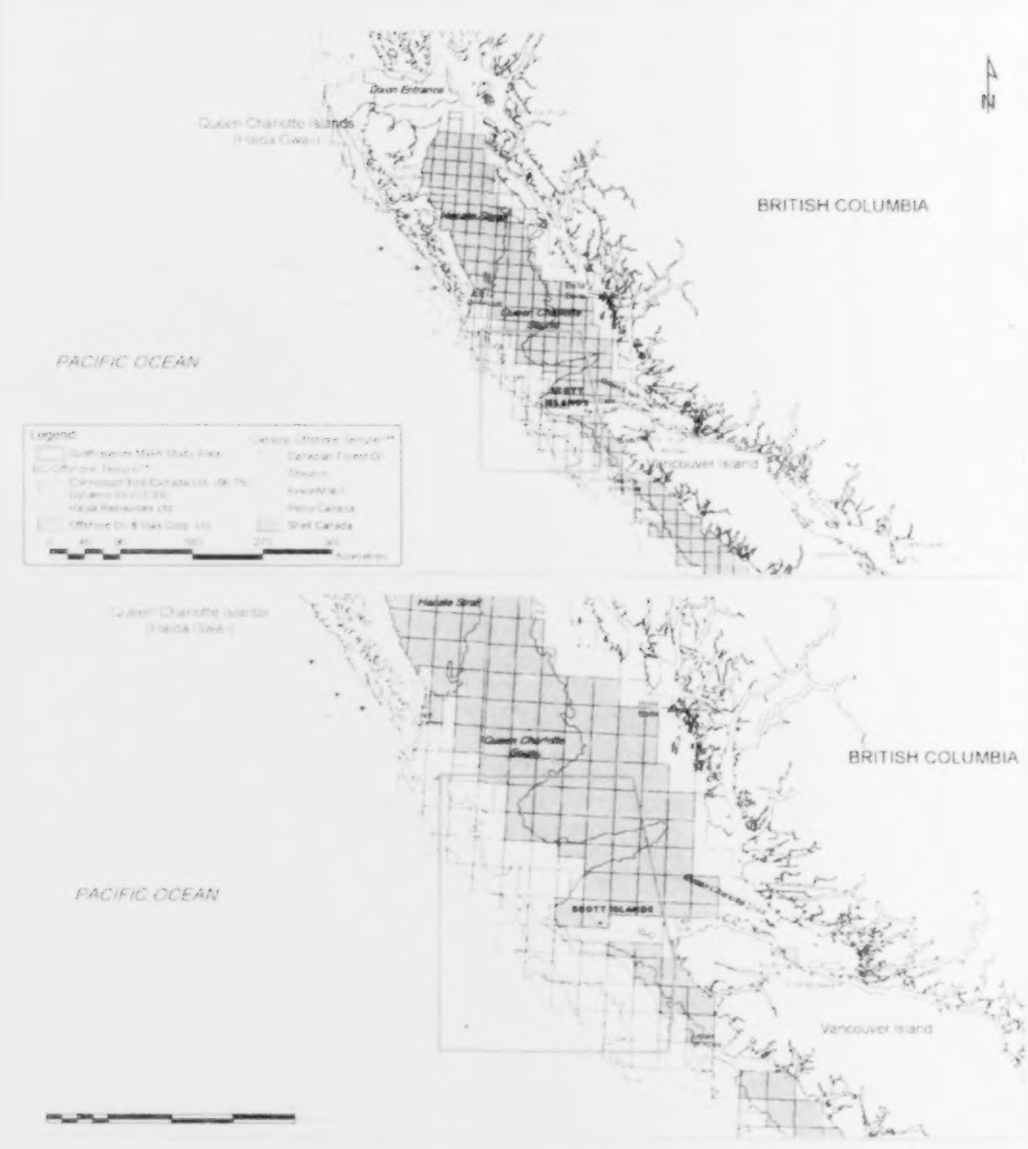

Figure B-8 Existing BC Offshore Petroleum Tenures

Data Source: Natural Resources Canada

9. Seabird Knowledge Gaps and Research Priorities

9.1 Common Murre Demographic and Population Information

Regional Common Murre (COMU, *Uria aalge*) population performance and demography has been identified as a high-priority knowledge gap. Results of surveys in 1989 and 2003 suggest that the Common Murre population at Triangle Island has declined, and if so, this could reflect a real region-wide decline or be due to birds dispersing to other areas (Triangle Island Seabird Research Station, unpublished data). Note that Triangle historically has supported > 95% of all breeding COMU in BC. Common Murre populations are declining elsewhere in parts of their range along the Pacific Coast, particularly in Washington State (Carter *et al.* 2001). In these areas, anthropogenic factors, such as oiling and bycatch in gillnet fisheries, may have contributed to observed declines (Carter *et al.* 2001). The declines in British Columbia, if real, may be due to factors operating outside the breeding season, as those birds that do breed at Triangle tend to be successful (Triangle Island Seabird Research Station, unpublished data). In collaboration with partners in Parks Canada and other agencies, a CWS seabird biologist is planning surveys in 2004 to determine whether Common Murres are in fact declining regionally. In addition, demographic studies of the Triangle population are underway (M. Hipfner, pers. comm.).

9.2 Population Impact of Fisheries Bycatch

The extent to which local and migrant seabird populations are affected or vulnerable to fisheries bycatch is being examined by a CWS marine conservation biologist. Seabirds are killed on longlines and in nets. Black-footed Albatrosses (*Phoebastria nigripes*) appear to be the most common bycatch on longlines in BC, but gulls (Herring [*Larus argentatus*] and California [L. californicus]), Short-tailed Shearwaters (*Puffinus tenuirostris*), and Northern Fulmars (*Fulmarus glacialis*) have also been caught. Common Murres and Rhinoceros Auklets (*Cerorhinca monocerata*) are the species most often reported caught in gill nets, although Common Loons, Pelagic Cormorants, Pigeon Guillemots and Marbled Murrelets have also been inadvertently killed (K. Morgan, unpublished data). Although the marine areas where coastal breeders forage is fairly well understood, almost nothing is known of the at-sea distribution of both the local breeders and the winter visitors. This information is critical to the identification of risks to local birds in space and time. Traditional banding methods are of limited utility for determining winter distributions, due to low recovery rates. Therefore, a satellite-telemetry research program has been proposed to address this issue. Common Murres, which may be declining locally, will be a focal species, as they are known to be negatively impacted by gillnet fisheries elsewhere in their range (K. Morgan, pers. comm., Carter *et al.* 2001). However, other species would ideally also be included in this project.

9.3 Forage Fish Life History and Ecology

Little is known about basic ecology of Sandlance (*Ammodytes hexapterus*) and other forage fish in BC waters. For example, Rhinoceros Auklet fledgling diet is known to shift from predominantly Pacific Sandlance in the early breeding season (i.e. June to mid-July) to predominantly Pacific Saury (*Cololabis saira*) later in the breeding season. These fish are similar in shape and energetic value, and the diet shift is thought to be related to the seasonal availability of these species, although this is not known. Also unknown is whether these two species differ in spatial distribution. The telemetry work on Rhinoceros Auklets to date has focused on late breeding season (MacFarlane *et al.* in prep.), so few conclusions can be drawn at this point regarding foraging distribution of this species during the period in which Rhinoceros Auklets are preying on Pacific Sandlance. Common Murres have been observed to shift from Pacific Sandlance to juvenile rockfish at approximately the same time, supporting the hypothesis that prey availability drives the disappearance of Sandlance from the diet (Triangle Island Seabird Research Station, unpublished data). This appears to have important implications for species such as Rhinoceros Auklet and Tufted Puffin that feed their chicks largely on forage fish (Gjerdrum *et al.* 2003).

9.4 Adult Diet Composition

Although seabird nestling diet composition has been fairly well studied, much less is known about the food items consumed by the adults, either during the breeding season or during the rest of the year. Adult and nestling diets often differ significantly. Isotopic studies elsewhere have indicated that chicks are feeding at a higher trophic level than their parents, indicating that adult seabirds often feed nestlings diet items that differ from those that they feed themselves (Hodum and Hobson 2000). Isotopic analyses of five breeding alcids species at Triangle Island in 2002 confirmed that adults and chicks of all species do have distinct signatures. This line of research is being pursued through the examination of isotopic signatures of adult Rhinoceros Auklets and Cassin's Auklets during the pre-laying, incubation, and chick phases, as well as egg and chick signatures. Understanding the feeding tendencies of adults will enable researchers to better understand seabird distribution patterns and constraints on adult survival throughout the year.

9.5 Population Impact of Chronic Oil Spills

At this time, the extent of background chronic oil pollution and its consequent impacts on seabirds is unknown in BC. Spatial and temporal overlapping of dense aggregates of vulnerable seabird species and intense shipping traffic, similar to that found off the west coast of Canada, has been consistently associated with high seabird oiling rates both globally (i.e. Europe) and regionally (i.e. Newfoundland). In BC, results from both the Beach Bird Surveys (BBS, conducted by Bird Studies Canada) and the National Aerial Surveillance Program (NASP; conducted by Canadian Coast Guard) provide added incentive to determine population impacts of chronic oil spills to seabirds in British Columbia. The mean proportion of the total bird carcasses that were found oiled, for all beaches surveyed in the BBS, was approximately 12%, however; 56% of all carcasses found along the west coast of Vancouver Island were oiled. Although BBS data can be useful for estimating oil associated seabird mortality in some locations, interpretation is constrained due to often unavoidable biases associated with data collection. In particular, in most areas along the west coast, bird distributions and shipping traffic interact with wind and ocean currents resulting in unfavourable conditions for depositing oiled carcasses on shorelines. The west coast of Vancouver Island may be one of the few areas in BC where oiled carcasses are likely to drift ashore. NASP data (1997-2001) also provide inferential evidence that oil spills could be impacting BC seabirds. In this program, rates of spill observations are higher off the West Coast (per flight km) than off the East Coast of Canada, where seabird mortality that is untenable at the population level has been attributed scientifically to chronic oil spills. Thus impacts on seabird populations in BC may also be considerable, and these impacts would likely be exacerbated by potential future oil and gas exploration in the region.

Birds Oiled at Sea (BOAS), a University of Victoria research program supported by CWS and DFO, has been developed in order to investigate the impact of chronic oil spills on seabird populations in British Columbia. Visiting scientist Patrick O'Hara is developing a spatial risk model for seabirds and chronic ship-source oil pollution based on aerial survey data (NASP), ship traffic density information (MCTS), satellite imagery data (Integrated Satellite Tracking of Polluters initiative), and seabird distributions at sea (Ken Morgan – CWS pelagic bird surveys). He hopes to hope to identify seasonally, areas of high risk of contact between oil spills and seabirds, and estimate the probability that oiled carcasses from these areas would reach shorelines that are currently surveyed in the BBS program. This information will help us to better interpret BBS data and to improve our understanding of the magnitude of ship-source chronic oil pollution and its impact on BC seabirds.

9.6 Impacts of Climate Change

The extent to which seabird populations respond to changes in oceanographic conditions continues to be a focus for research, as these responses may allow researchers to predict possible consequences of global warming for seabird populations. The 20+ year pelagic seabird program continues to monitor the at-sea distribution of marine birds; examining the within and between year variability in the composition of, and the distribution and abundance of the species making up the offshore seabird community. The data are collected aboard Fisheries and Oceans vessels engaged in physical and biological oceanographic studies, which will allow future research into the response of seabirds to local and distant oceanographic variability (K. Morgan, pers. comm.) Although the effects of climate change are locally unmanageable l, thus limiting the ability to respond locally, the ability to distinguish if a species is being impacted by environmental/oceanographic changes or by some other cause (such as habitat loss) will aid CWS in its mandate to conserve seabird populations (M. Hipfner and K. Morgan, pers. comm.).

9.7 Storm-petrel Demographic and Population Information

Storm-petrels represent another locally breeding taxon about which little is known. Populations of both Forked-Tailed (*Oceanodroma furcata*) and Leach's (*O. leucorhoa*) storm-petrels breed in the Scott Group, but there is currently no information about their status or demography. As late-breeding planktivores, Leach's Storm-petrels, perhaps even more than early-breeding Cassin's Auklets, may well have been adversely affected by the generally warm oceanographic conditions in the mid-to-late 1990s, which caused a temporal shift towards early zooplankton biomass peaks (Bertram *et al.* 2001). Banding operations for Leach's Storm-petrel commenced on Triangle in 2003, with the primary aim of establishing baseline data on population trends and demography.

9.8 Cormorant Population Information

Very little is known about population processes in locally-breeding cormorant populations, including the Sartine breeding colony of Brandt's Cormorants (*Phalacrocorax penicillatus*). Pelagic cormorants also breed on the Scott Islands.

9.9 Pigeon Guillemot Population Information

There is relatively little known about the biology of Pigeon Guillemots (*Cepphus columba*) in the Pacific and Yukon Region, but there is anecdotal evidence of local population declines in recent years at Triangle Island (Triangle Island Seabird Research Station, unpublished data). This species is difficult to study, as it is only loosely colonial, nests in inaccessible rock crevices, and can be sensitive to researcher disturbance.

9.10 Risk and Recovery Uncertainties

The complex marine ecosystem contained within the Scott Islands MWA study area is understood well enough to conclude that it is predictably sensitive to some aspects of climate variability (Bertram *et al.* 2001). For example, seabird mortality tends to be higher during El Niño years. Therefore large-scale fluctuations in oceanographic conditions associated with climate stresses would be expected to result in pronounced effects on distribution and productivity of aquatic and avian biota in the region. Mortality in addition to that caused by climate fluctuations, in particular anthropogenic impacts such as chronic or catastrophic oil spills and seabird bycatch, may result in immediately measurable declines in local populations of seabirds. Given the low reproductive rate and known sensitivity of seabird breeding success to climate and oiling, recovery will be slow. Indeed declines in population numbers may continue for many years following an adverse event. Researchers at the Canadian Wildlife Service are concerned with the potential acute and chronic effects of anthropogenic effects of oiling and bycatch on seabird sustainability. Motivated by this concern, they are evaluating the need for the development of risk and recovery assessment models to determine the long term vulnerability of the local populations to potential sources of anthropogenic mortality.

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Appendix A. Agencies and Organizations Contacted.

BC Ministry of Management Services
BC Ministry of Water, Land, and Air Protection
Canadian Wildlife Service
Dalhousie University
Ducks Unlimited Canada
Fisheries and Oceans Canada
International Pacific Halibut Commission
Meteorological Service of Canada
National Aeronautics and Space Administration
Natural Resources Canada
Oregon State University
Simon Fraser University
University of British Columbia
Vancouver Aquarium

Appendix B. List of Internationally and Nationally Recognized Endangered Species as of November 2005.

Taxon	Common Name	Scientific Name	IUCN Risk Category *	COSEWIC Risk Category **	SARA Status ***
Birds	Marbled Murrelet	*Brachyramphus marmoratus*	VU	Threatened	Schedule 1
	Ancient Murrelet	*Synthliboramphus antiquus*		Special Concern	Consultations
	Peregrine Falcon pealei	*Falco peregrinus pealei*		Special Concern	Schedule 1
	Pink-footed Shearwater	*Puffinus creatopus*	VU	Threatened	Schedule 1
	Short-tailed Albatross	*Phoebastria albatrus*	VU	Threatened	Schedule 1
	Black-footed Albatross	*Phoebastria nigripes*	EN		
	Laysan Albatross	*Phoebastria immutabilis*	VU		
Mammals	Sei Whale	*Balaenoptera borealis*	EN	Endangered	Schedule 1
	Fin Whale – Pacific	*Balaenoptera physalus*	EN	Threatened	Consultations
	Blue Whale	*Balaenoptera musculus*	EN	Endangered	Schedule 1
	Killer Whale – Southern Resident	*Orcinus orca*	LR cd	Endangered	Schedule 1
	Killer Whale – Northern Resident	*Orcinus orca*	LR cd	Threatened	Schedule 1
	Killer Whale – Transient	*Orcinus orca*	LR cd	Threatened	Schedule 1
	Killer Whale - Offshore	*Orcinus orca*	LR cd	Special Concern	Schedule 1
	Baird's Beaked Whale	*Beradius bairdii*	LR cd		
	Grey Whale – Northeast Pacific	*Eschrichtius robustus*	LR cd	Special Concern	Schedule 1
	Humpback Whale – North Pacific	*Megaptera novaeangliae*	VU	Threatened	Schedule 1
	Sperm Whale	*Physeter macrocephalus*	VU		
	Right Whale – North Pacific	*Eubalaena japonica*	EN D	Endangered	Consultations

Taxon	Common Name	Scientific Name	IUCN Risk Category *	COSEWIC Risk Category **	SARA Status ***
	Harbour Porpoise – Pacific	*Phocoena phocoena*	VU	Special Concern	Schedule 1
	Dall's Porpoise	*Phocoenoides dalli*	LR		
	Steller Sea Lion	*Eumetopias jubatus*	EN	Special Concern	Schedule 1
Fish	Tope Shark	*Galeorhinus galeus*	VU		
	Basking Shark	*Cetorhinus maximus*	VU		
	Bocaccio	*Sebastes paucispinis*		Threatened	Consultations
	Bluntnose Shark	*Hexanchus griseus*	LR nt		
	Blue Shark	*Prionace glauca*	LR nt		
	Spiny Dogfish	*Squalus acanthius*	LR nt		
	Big Skate	*Dipturus binoculata*	LR		
Reptiles	Leatherback Turtle	*Dermochelys coriacea*	CR	Endangered	Schedule 1
Molluscs	Northern Abalone	*Haliotis kamtschatkana*		Threatened	Schedule 1

* International Union for Conservation of Nature and Natural Resources
IUCN Risk Categories, as defined in IUCN (1994, 2001)
CR – Critically Endangered
EN- Endangered
VU – Vulnerable
LR cd – Lower Risk, conservation dependent (i.e. if current conservation efforts ceased, species would enter one of the higher conservation categories noted above)
LR nt – Lower Risk, near threatened (i.e. taxa which do not qualify for LR cd, but which are close to qualifying for Vulnerable)
** Committee on the Status of Endangered Wildlife in Canada
*** Species at Risk Act
Schedule 1 – The official list of wildlife species at risk in Canada.
Schedule 2 – COSEWIC species listed as Endangered and Threatened that must be re-assessed under the new criteria before addition to Schedule 1.
Schedule 3 – COSEWIC species listed as Special Concern that must be re-assessed under the new criteria before addition to Schedule 1.
Consultations – Species determined by COSEWIC to be at risk in Canada, and being considered for addition to Schedule 1.